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A Vision of Theater Air Defense Battle Management Command and Control in 2010

Edward R. Harshberger, Richard Mesic

Project AIR FORCE

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A Vision of Theater Air Defense Battle Management Command and Control in 2010

Edward R. Harshberger, Richard Mesic

Prepared for the
United States Air Force

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Project AIR FORCE

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PREFACE

This documented briefing was prepared as an input to the evolving service and joint debate over the nature of future theater air defense (TAD) operations. The debate concerning battle management and command and control (C2) is coordinated by the TAD C2 CONOPS Panel, under the authority of the Executive Agent for TAD battle management command, control, communications, computers, and intelligence (BMC4I). This briefing responds to a specific request for inputs by the Executive Agent.

TAD project research is conducted in the Force Modernization and Employment Program within RAND's Project AIR FORCE. This briefing should be of interest to anyone concerned with theater air defense and command and control issues.

PROJECT AIR FORCE

Project AIR FORCE, a division of RAND, is the Air Force federally funded research and development center (FFRDC) for studies and analyses. It provides the Air Force with independent analyses of policy alternatives affecting the development, employment, combat readiness, and support of current and future aerospace forces. Research is performed in three programs: Strategy and Doctrine, Force Modernization and Employment, and Resource Management and System Acquisition.

SUMMARY

INTRODUCTION

The 2010 theater air defense (TAD) vision in this documented briefing was developed as a natural extension of the 2003 vision that is the current (FY96) focus of the TAD command and control (C2) CONOPS panel of the Executive Agent for Theater Air Defense battle management command, control, communications, computers, and intelligence (BMC4I). The TAD systems that will be available in 2003 are now fairly well established, but the situation for 2010 is less clear. Consequently, we were able to extend the 2003 vision without many of the constraints faced in 2003. Because of the panel's focus on 2003, the 2010 vision is less well developed and detailed than is the nearer-term 2003 vision. Nevertheless, the analysis framework and themes developed here may be of value as the long-range vision is refined in FY97 and beyond.

There is another well publicized vision for 2010—the Chairman's Joint Vision 2010. We have attempted in our TAD vision to reflect the major themes of his vision. Our challenge, as in many other mission areas, is to describe how TAD operations will contribute to meeting the objectives of the chairman's 2010 vision—applying the themes of dominant maneuver, precision engagement, full-dimension protection, and dominant battlefield awareness to successful accomplishment of theater air defense.

There are at least two ways to develop a future vision: technology push and demand pull. We have adopted a demand pull approach that is firmly rooted in operational issues. TAD operations in 2010 will have strong threads of continuity with TAD operations of today and 2003. These threads help us focus on and highlight those future changes that are more "visionary" by making them stand out clearly from the enduring baseline.

ENDURING ELEMENTS OF TAD

At the highest level, some principles of warfare are likely to endure. TAD operations in 2010 will surely be joint. U.S. forces (and, most likely, coalition forces) will operate under the command of a Joint Force Commander (JFC). Component commanders will be delegated responsibility and authority to

conduct TAD operations. For our purposes, it is not important exactly how those responsibilities are delegated and packaged (e.g., the specific roles of the Joint Force Land Component Commander (JFLCC), the Joint Force Air Component Command (JFACC), Area Air Defense Commander (AADC) or a possible new entity called a Joint Force Air and Missile Defense Commander (JFAMDC)). These doctrinal debates will be resolved in other forums.

Basic TAD *tasks* will not change dramatically by 2010. Theater military operations to counter effective enemy use of theater air and missile threats will likely continue to consist of both offensive and defensive operations, with four distinct but mutually supporting main tasks of (1) attack on fixed targets, (2) attack on short-dwell time mobile targets, (3) active defense against manned aircraft, and air-breathing and ballistic missiles, and (4) passive defense.

Our high-level TAD 2010 vision focuses on the first three of these tasks; passive defenses are not considered explicitly. Although passive defenses are likely to be important responses to TAD threats and much needs to be done to enhance detection, warning, dispersal, and hardening capabilities, the unique character of passive defenses calls for separate treatment beyond the scope of this effort.

In the future, certain key *functions* must be performed to accomplish all necessary TAD tasks. Figure S.1 illustrates an operational concept "thread" through the key functions for an active defense task. The functional processes and terminology are drawn from the Executive Agent's "As-Is Architecture," with corresponding numbering. This operational concept description emphasizes the monitoring, assessing, and execution functions. It shows an end-to-end activity stream than ends in neutralizing the threat and evaluating the outcome.

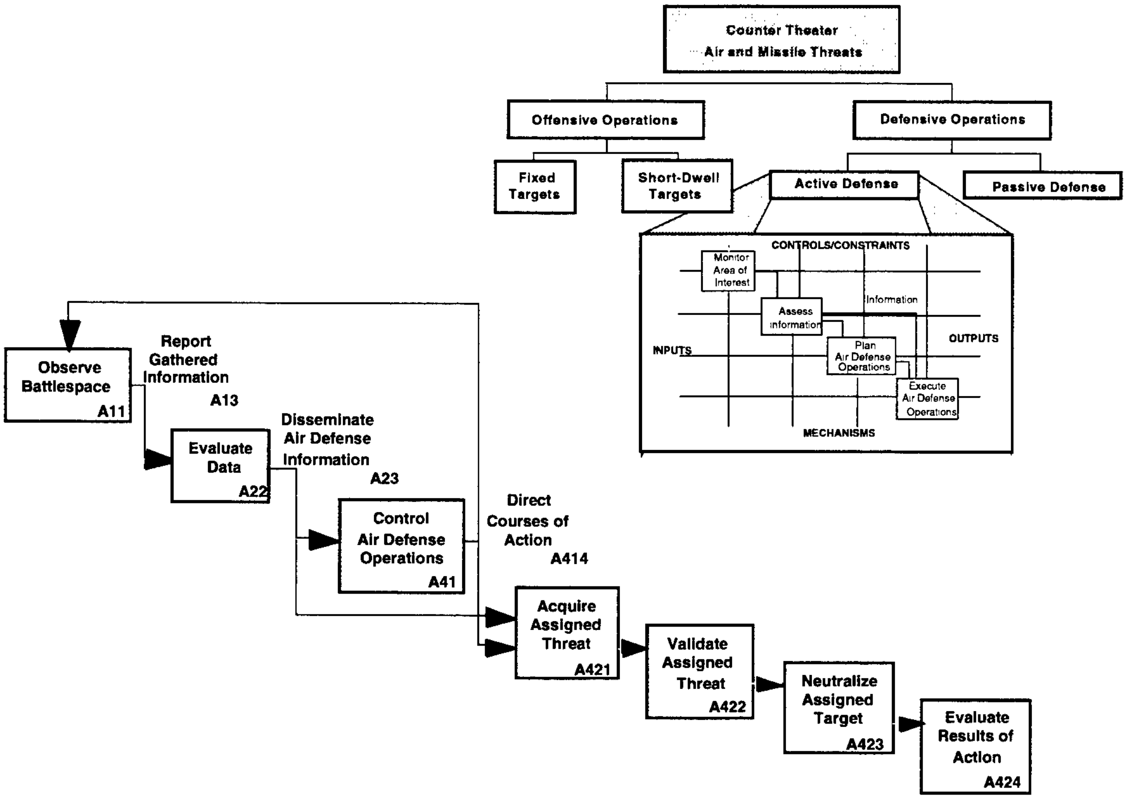

Figure S.1—Now and in the Future, Key Functions *Must* Be Performed

So far, we have identified what will likely be the same in TAD operations today and in 2010. However, there are two aspects of what we've discussed that will likely change. The first is the *relative importance* of the four main TAD tasks. Relative and absolute investment levels in offensive and defensive operations may change. For example, in the NATO/Warsaw Pact standoff in Central Europe the emphasis was on passive defenses (concealment, mission-oriented protective posture [MOPP] gear, rapid runway repair, etc.). Now, with a shift in focus to other major regional conflicts (MRCs), the emphasis is on active defenses to better protect regional allies and U.S. forces and facilities (e.g., garrisons, ports, and airfields). [1]

Changes in both threat technologies and systems, as well as changes in TAD technologies and systems, can also change the *way we perform* the seven

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[1] Changes in emphasis may also occur within defensive operations. For instance, we see an emerging debate between ballistic and cruise missile defense arising from both threat developments and technological opportunities.

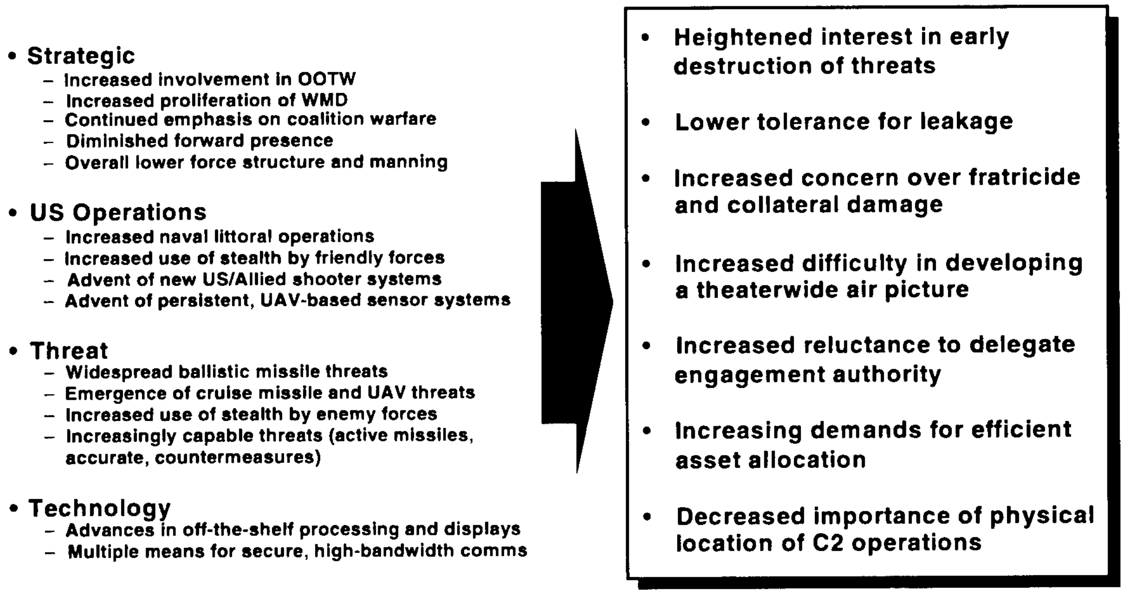
functions in the figure above. Functions might be aggregated or performed in parallel, with shifts in where and by whom they're performed. For example, "observe battlespace" could be at a centralized command facility or it could be on proliferated sensor platforms such as unmanned air vehicles (UAVs).

In summary, the basic TAD operational framework (objectives, tasks, and functions) will likely stay the same, but the details will change. We'll next turn to a discussion of trends that will lead to changes in these details.

CHANGES AND TRENDS

Our trend assessment focused on four main trend areas: (1) strategic (in the sense of "essential in relation to strategy"), (2) U.S. operations, (3) threat, and (4) technology.

These general trends can be directly related to TAD-specific challenges and opportunities, as shown in Figure S.2. These challenges and opportunities constitute a new future operating environment for theater air and missile defenses, one that will require new approaches and solutions in a wide range of contexts from operations other than war (OOTW) to MRCs waged under the shadow of weapons of mass destruction (WMD).



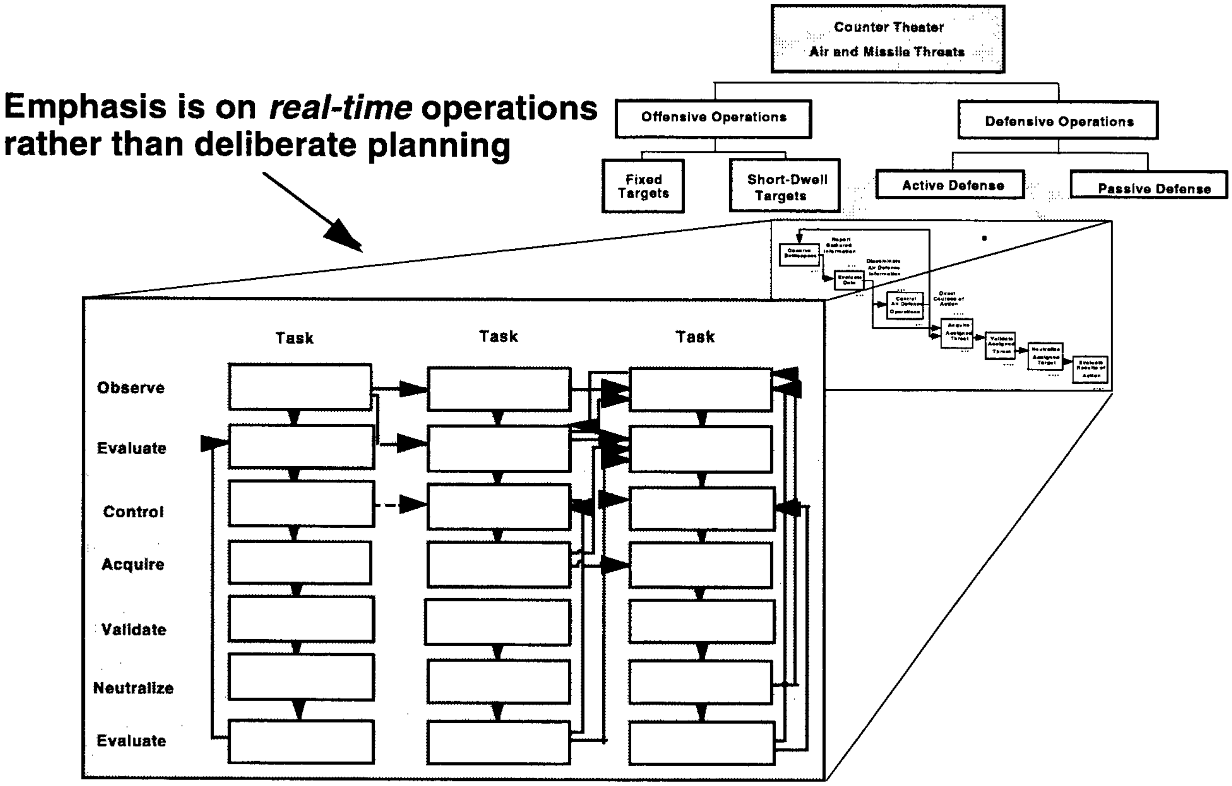
- **Strategic**
  - Increased involvement in OOTW
  - Increased proliferation of WMD
  - Continued emphasis on coalition warfare
  - Diminished forward presence
  - Overall lower force structure and manning
- **US Operations**
  - Increased naval littoral operations
  - Increased use of stealth by friendly forces
  - Advent of new US/Allied shooter systems
  - Advent of persistent, UAV-based sensor systems
- **Threat**
  - Widespread ballistic missile threats
  - Emergence of cruise missile and UAV threats
  - Increased use of stealth by enemy forces
  - Increasingly capable threats (active missiles, accurate, countermeasures)
- **Technology**
  - Advances in off-the-shelf processing and displays
  - Multiple means for secure, high-bandwidth comms

- **Heightened interest in early destruction of threats**
- **Lower tolerance for leakage**
- **Increased concern over fratricide and collateral damage**
- **Increased difficulty in developing a theaterwide air picture**
- **Increased reluctance to delegate engagement authority**
- **Increasing demands for efficient asset allocation**
- **Decreased importance of physical location of C2 operations**

Figure S.2—Trends Lead to a New Future Environment for TAD Operations

KEY FUTURE BMC4I DEMANDS

We have adopted a matrix methodology to derive and display future TAD BMC4I demands (see Figure S.3). Functions are performed to accomplish the tasks, and the interconnecting arrows show information flow. Our emphasis is on real-time operations and C2 rather than deliberate planning.



Emphasis is on *real-time* operations rather than deliberate planning

Figure S.3—Methodology for Characterizing TAD BMC4I Demands

Given this real-time focus, our analyses centered on four tasks: (1) offensive operations (pre-launch attacks), (2) offensive operations (post-launch attacks), (3) defensive operations (intercept of ballistic threats), and (4) defensive operations (intercept of air-breathing threats).

Our analysis of TAD BMC4I to support *offensive operations* centers on fusion and allocation. Fusion will be increasingly critical in TAD offensive operations to exploit all information sources to find hidden and/or mobile targets. It is obvious that the more information that can be used in any TAD operation, the

better. Beyond this truism, there are less obvious cases in which fusion is not only valuable but essential.

Allocation concerns reflect the emergence and proliferation of specialized sensor platforms such as UAVs, which, as with JSTARS (Joint Surveillance Target Attack Radar System) in the Gulf War, may serve multiple masters and needs (e.g., intelligence, reconnaissance, surveillance, targeting, bomb damage assessment [BDA]). TAD offensive operations themselves will involve critical sensor allocation decisions (e.g., area coverage, response to cueing, search and ID, etc.). How will these allocation decisions, many likely to require real-time action, be managed?

With respect to *active air and missile defense operations*, it is clear that both the need and opportunity exist for much better situational awareness at all command levels. A key element is the real-time air picture, which should be able to show the ID, status, and track for all aerospace objects—friend, foe, and neutral (IFFN). This air picture, if feasible, will also go a long ways toward solving the pressing combat ID (IFFN) problems that limit defense effectiveness. With the proliferation of threats and defense assets (some of which—such as interceptor aircraft and surface-to-air missiles (SAMs)—are multimission-capable), allocation issues, including real-time direction, must be addressed.

Finally, we believe there will be a heightened need for more flexible TAD operational C2 solutions in the future. Air operations in Bosnia are just one example of OOTW that may increasingly stress C2 capabilities. Zero tolerance for errors, for example, results in a reluctance by political leadership and command elements to delegate responsibility anad authority and to instead exercise near-real-time command and control at high levels. As technology allows ever-greater centralized control, operations will be rapidly adapted to unique circumstances. How can this type of operational flexibility best be incorporated in TAD operations circa 2010?

A VISION OF FUTURE TAD BMC4I

Our 2010 vision is our view of the future. Others, who may approach the problem from a different perspective, may see things differently. Our hope is that the thought process and methodology behind our vision are helpful in advancing reasonable TAD solutions to accepted strategic and tactical goals. The linkage between goals and objectives and TAD CONOPS and BMC4I

systems may be the principal value of this work. This vision is, at best, a beginning, but it does provide a framework for addressing contemporary issues such as the proper role for cooperative engagement capability (CEC)-like systems, cruise missile threat implications, and balanced TAD architectures to address emerging WMD problems.

In our 2010 TAD vision there will be a **centralized joint fusion center** to enable much more effective offensive operations against short dwell threats such as missile transpositor-erector-launchers (TELs). We envision a highly centralized, manpower-intensive facility (location may be unimportant).

Our 2010 vision also includes a single, **real-time fused air picture** that all force elements can access and update. The idea is simple and appealing; the detailed implementation, of course, may not be so simple. The potential value is obvious, and may be reasonable as early as 2010. A full suite of enabling technologies is maturing—technologies and systems include the Global Positioning system (GPS); global broadcast system (GBS); Joint Tactical Information Distribution System (JTIDS); CEC; computers, track algorithms, and displays; and low probability of intercept (LPI) satellite communications.

The 2010 vision includes truly **integrated joint air and missile defense operations**. Defense assets would be allocated optimally from the theater commander's perspective and real-time engagement control would minimize leakage against uncertain threat objectives and tactics. Appropriate command levels would automatically be tasked and enabled depending on the threat and (possibly changing) defense missions and priorities (e.g., preferential defenses).

A critical element of the 2010 vision addresses the local **IFFN** problem and the global air picture problem. We note that LPI communications links through satellites, when coupled with GPS position data, ought to enable the United States to keep accurate track of all U.S. aircraft, even stealthy ones.

The elements of this vision should not be constrained by communications links. In 2010 (and 2003) multiple means of secure, high-bandwidth communications (military and commercial) will be available in most conceivable theaters, enabling a tailorable "on-demand" communications system for most needs given reasonable planning.

We have focused our vision on the few critical issues facing future TAD BMC4I. We have attempted to support this particular focus with a strategies-to-tasks and process assessment consistent with general technology trends (as

opposed to specific systems concepts). However, we recognize that our vision is evolutionary—even "conventional"—in its assumptions, scope, and analytic approach. We believe this is appropriate, but we also recognize that there are threat trends and uncertainties (e.g., WMD) that could force more revolutionary changes in the way the United States conducts military operations—to include TAD.

A Vision for TAD BMC4I in 2010

RAND Theater Air Defense Project
October 1997

This briefing was developed as an input to the evolving Service and Joint debate over the nature of future theater air defense (TAD) operations. The debate concerning battle management and command and control (C2) is being coordinated by the TAD C2 CONOPS (concept of operations) Panel, under the authority of the Executive Agent (EA) for TAD battle management command, control, communications, computers, and intelligence (BMC4I) . This briefing responds to a specific request for inputs by the Executive Agent.

Background

- **Ongoing EA activity aimed at developing a TAD C2 Plan**
  - CONOPS development is key part of this effort
  - RAND effort aimed at supporting CONOPS panel, with emphasis on 2010 vision
- **Vision for 2010 (current CONOPS outline)**
  - Discussion will include a look at expected changes in the threat and potential technology and systems upgrades that will allow us (or may require us) to do command and control of these operations differently in 2010. It will be a logical extension of the changes we project for 2003, but will not be as detailed a discussion as was done for 2003.

This 2010 vision was developed as a natural extension of the 2003 vision that is the focus of the TAD C2 CONOPS panel.

The TAD systems that will be available in 2003 are now fairly well determined, but the situation for 2010 is less clear. Consequently, we were able to extend the 2003 vision without many of the constraints faced in 2003. Because of the panel's focus on 2003, this 2010 vision is less well developed and detailed than is the much-nearer-term 2003 vision. Nevertheless, the analysis framework and themes developed here may be of enduring value as this long-range vision is refined in FY97 and beyond.

The Context: Joint Vision 2010

- **Joint Vision 2010 provides the guiding principles for U.S. operations in 2010**
  - **Dominant Maneuver**
  - **Precision Engagement**
  - **Full-Dimension Protection**
  - **Dominant Battlefield Awareness**
- **For each mission area, TAD included, we must provide the details of how this vision is to be fulfilled**
- **This briefing largely parallels the structure of JV2010, with focus on TAD and TAD BMC4I**

There is another well-publicized vision for 2010—the Chairman's Joint Vision 2010. We have attempted in our TAD vision to reflect the major themes of his vision.

Our challenge, as in many other mission areas, is to provide a description of how TAD operations will contribute to meeting the objectives of the chairman's 2010 vision—applying the themes of dominant maneuver, precision engagement, full-dimension protection, and dominant battlefield awareness to successful accomplishment of theater air defense.

Two Lenses Through Which to View the Future

- **Technology Push**
  - Focus is on the possibilities that technological change will create, usually upbeat
  - Such visions are usually less than specific about operational issues, or imply revolutionary changes

- **Demand Pull**
  - Focus is on the new and/or persistent demands that change (technological/operational) will create
  - Since such visions require a definition of operations (to create demand), they are generally more evolutionary in nature

This Briefing

There are at least two ways to develop a future vision: technology push and demand pull. Technology push focuses on emerging technologies and explores ways of exploiting those technologies in military operations. For example, technologists might hold out the promise of significantly higher computing power or worldwide secure cellular communications nets. The visionary then says: what can we do with this stuff?

The other approach, demand pull, is the one we have adopted for this briefing. It is firmly rooted in operational issues. For example, TAD operations today may be handicapped by relatively poor situational awareness. The visionary asks: are there technologies and systems coming along that can help me solve this problem? The virtue of this approach is that it maintains a strong focus on the job to be done (as opposed to potential tools for doing *some* job, as in the technology push approach). The problem, although not serious in our view, is that the demand pull vision is evolutionary since it starts with the current state of affairs and asks how can we do it better (more effective, less costly, lower risk). The demand pull approach, of course, must reflect a view of what "reasonable" technological apportunities might emerge. Our approach, therefore, is

actually a mix of the pure technology push/demand pull approaches, with the emphasis on demand pull.

Outline

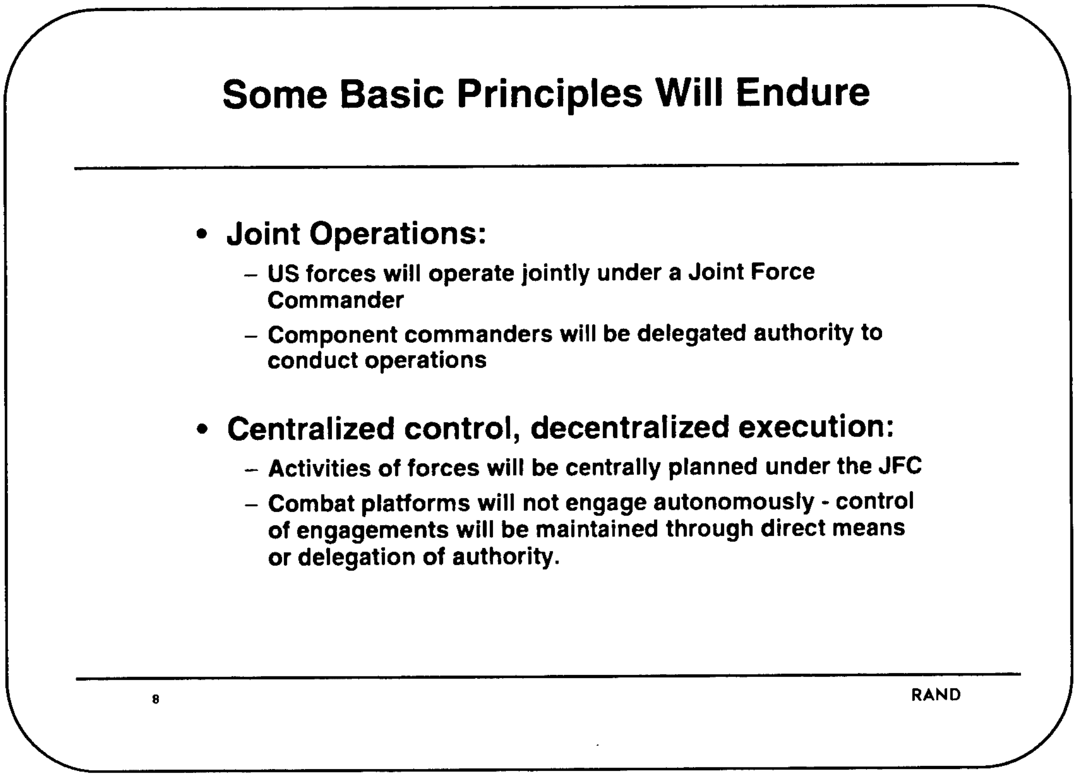
- Enduring Elements of TAD
- Changes and Trends
- Key Future BMC4I Demands
- A Vision of Future TAD BMC4I

Consistent with our demand pull approach, we will begin by discussing the threads of continuity between today's TAD operations and the likely operational requirements and approaches in 2010. We will find much that will stay the same, giving us a firm foundation on which to build enhanced capabilities. We will next develop, categorize, and assess strategic, operational, threat, and technology trends that may change TAD operations in 2010. Finally, we will summarize the effects of these trends, leading to our brief characterization or vision of TAD CONOPS in 2010.

Threads of Continuity

- **Visions – almost by definition – tend to focus on change.**
  - **Everyone should know that the future will not be the same as the past–the only future certainty is uncertainty**
  - **The differences are often the interesting parts**
- **However, the parts of the world that do *not* change are often just as important.**
- **Important threads of continuity will link TAD and TAD BMC4I operations today with those of the future.**

We believe, as demonstrated on the next several charts, that TAD operations in 2010 will have strong threads of continuity with TAD operations of today and 2003. These threads will help us focus on and highlight those future changes that are more "visionary" by making them stand out clearly from the enduring baseline.



Some Basic Principles Will Endure

- **Joint Operations:**
  - US forces will operate jointly under a Joint Force Commander
  - Component commanders will be delegated authority to conduct operations
- **Centralized control, decentralized execution:**
  - Activities of forces will be centrally planned under the JFC
  - Combat platforms will not engage autonomously - control of engagements will be maintained through direct means or delegation of authority.

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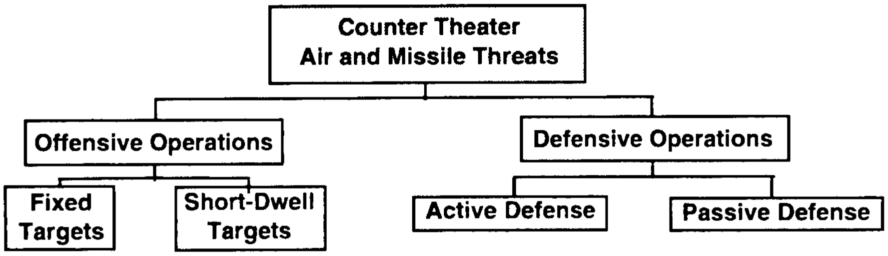
At the highest level, some principles of warfare are likely to endure. TAD operations in 2010 will surely be joint. U.S. forces (and, most likely, coalition forces) will operate under the command of a Joint Force Commander (JFC). Component commanders will be delegated responsibility and authority to conduct TAD operations. For our purposes, it is not important exactly how those responsibilities are delegated and packaged (e.g., the specific roles of the Joint Force Land Component Commander (JFLCC), Joint Force Air Component Commander (JFACC), Area Air Defense Commander (AADC), or a possible new entity called a Joint Force Air and Missile Defense Commander (JFAMDC). These doctrinal debates will be resolved in other forums.

For reasons we will explore later in the briefing, however, we envision that military operations will tend to be conducted with higher and higher levels of centralized control and decentralized execution. This clearly applies to major regional contingencies (MRCs), but it may be even more

characteristic of lesser regional contingencies and operations other than war (OOTW). Specifically, attacks will not be carried out autonomously. They will require human control and designated engagement authority from commanders. These requirements will stress C2 capabilities and may be an important forcing function for C2 investments.

Basic Theater Air and Missile Defense Tasks Will Not Change


Counter Theater Air and Missile Threats

Offensive Operations

Fixed Targets

Short-Dwell Targets

Defensive Operations

Active Defense

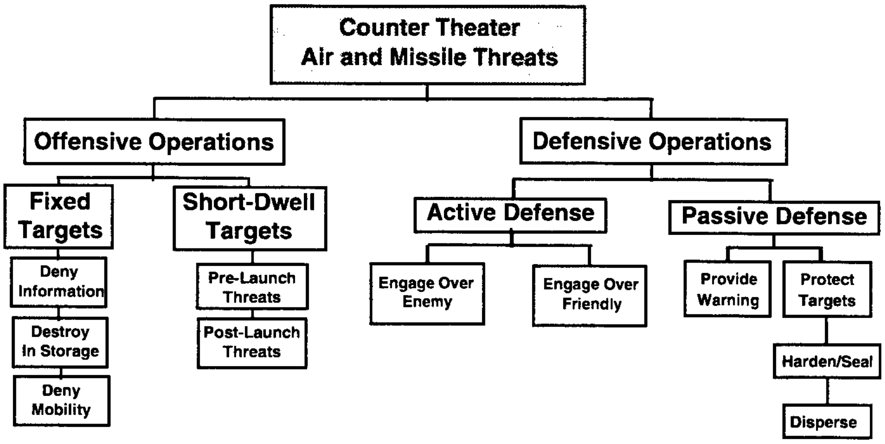
Passive Defense

TAD objectives and tasks are summarized above. In constructing this framework, the purpose was to use generic, non-service specific terms so as to avoid, to the extent possible, a contentious and diversionary "roles and missions" debate. (Terminology has been modified to conform to emerging joint doctrine in this area.)

Basic TAD *tasks* will not change dramatically by 2010. Theater military operations to counter effective enemy use of theater air and missile threats will likely continue to consist of both offensive and defensive operations, with four distinct but mutually supporting main tasks of (1) attacking fixed targets, (2) attacking short-dwell mobile targets, (3) active defense against air-breathing and ballistic missiles, and (4) passive defense.

The high-level TAD 2010 vision in this briefing will focus on the first three of these tasks; passive defenses will not be considered explicitly in what follows. Because no offensive operations or active defenses are likely to be perfect, passive defenses may be some of the most important responses to TAD threats. Much needs to be done to enhance our passive defenses, including improvements to our detection, warning, dispersal and hardening capabilities. The unique character of passive defenses calls for separate treatment beyond the scope of this effort.

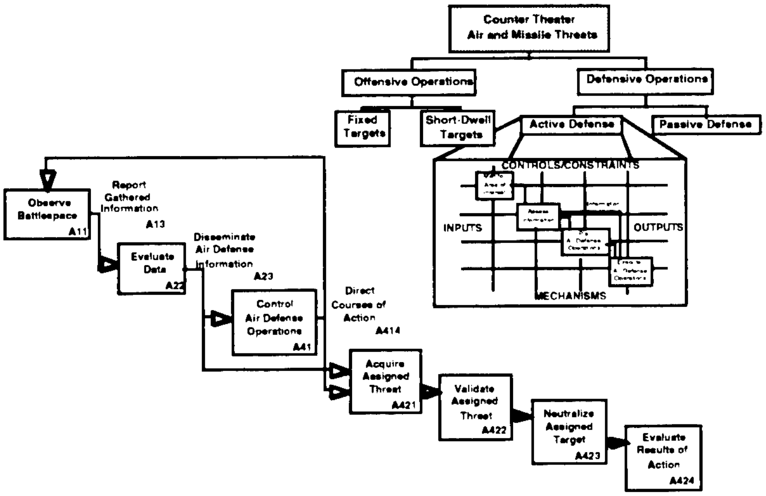
Basic Theater Air and Missile Defense Tasks Will Not Change



- Counter Theater Air and Missile Threats
  - Offensive Operations
    - Fixed Targets
      - Deny Information
      - Destroy In Storage
      - Deny Mobility
    - Short-Dwell Targets
      - Pre-Launch Threats
      - Post-Launch Threats
  - Defensive Operations
    - Active Defense
      - Engage Over Enemy
      - Engage Over Friendly
    - Passive Defense
      - Provide Warning
      - Protect Targets
        - Harden/Seal
        - Disperse

This chart reveals lower-level tasks to help the reader better understand the nature of the higher-level tasks on which we will focus. Again, even at this more specific level of detail, TAD tasks will not likely change dramatically by 2010.

Now and in the Future, Key Functions Must Be Performed



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Certain key functions must be performed to accomplish all necessary TAD tasks. The chart above illustrates an operational concept "thread" through the key functions for an active defense task. The functional processes and terminology are drawn from the Executive Agent's "As-Is Architecture," with corresponding numbering.

As noted previously, this operational concept description emphasizes the monitoring, assessing, and execution functions. It shows an end-to-end activity stream than ends in neutralizing the threat and evaluating the outcome. These seven functions will be used later in the briefing to characterize TAD BMC4I demands for each of the main tasks on the previous chart.

What <u>Will</u> Change in the Future?

- **Changed environments and strategies can change the relative importance of tasks**
  - May become more or less important
- **Changes in technologies (friendly and threat) can change how we perform functions**
  - Make difficult functions easy...or vice versa
  - Enable new ways of performing functions

So far, we've identified what will likely be the same in TAD operations today and in 2010. However, there are two aspects of what we've discussed to this point that will likely change. The first is the relative importance of the four main TAD tasks. Relative and absolute investment levels in offensive and defensive operations may change. For example, in the NATO/Warsaw Pact standoff in Central Europe, the emphasis was on passive defenses against missile threats (concealment, mission-oriented protective posture [MOPP] gear, rapid runway repair, etc.). Now, with a shift in focus to other MRCs, the emphasis is on active defenses to better protect regional allies and U.S. forces and facilities (e.g., garrisons, ports, and airfields).[1]

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[1] Changes in emphasis may also occur within defensive operations. For instance, we see an emerging debate between ballistic and cruise missile defense arising from both threat developments and technological opportunities.

Changes in both threat technologies and systems, as well as changes in TAD technologies and systems, can also change the way we perform the seven functions on the previous chart. Functions might be aggregated or performed in parallel, with shifts in where and by whom they're performed. For example, "observe battlespace" could be at a centralized command facility or it could be on proliferated sensor platforms such as unmanned air vehicles (UAVs).

What Will Change in the Future?

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  - May become more or less important
- **Changes in technologies (friendly and threat) can change how we perform functions**
  - Make difficult functions easy...or vice versa
  - Enable new ways of performing functions

Bottom Line:
Details Change, Framework Stays the Same

In summary, the basic TAD operational framework (objectives, tasks, and functions) will likely stay the same, but the details will change. We'll next turn to a discussion of trends that will lead to changes in these details.

Outline

- **Enduring Elements of TAD**
- **Changes and Trends**
- **Key Future BMC4I Demands**
- **A Vision of Future TAD BMC4I**

Our trend assessment will be decomposed into four main areas: (1) strategic, (2) U.S. operations, (3) threat, and (4) technology. We'll discuss each of these areas in turn on the next four charts.

TAD-Related Trends

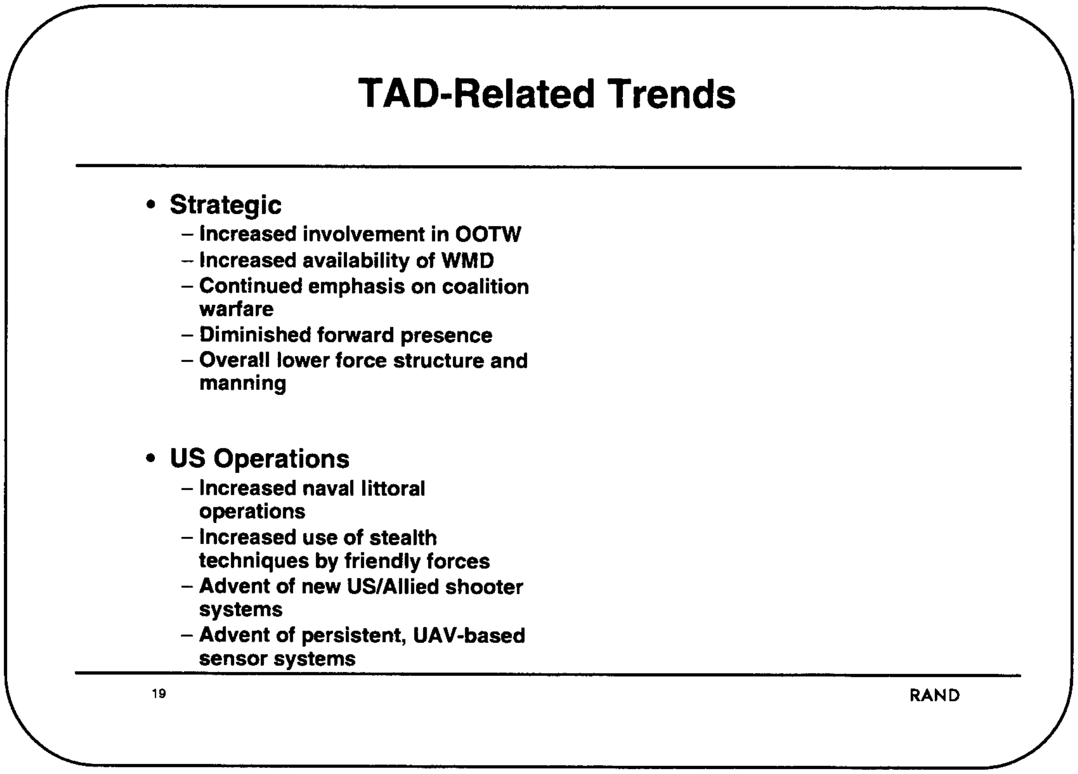
- **Strategic**
  - Increased involvement in OOTW
  - Increased availability of WMD
  - Continued emphasis on coalition warfare
  - Diminished forward presence
  - Overall lower force structure and manning

The strategic TAD-related trends outlined above are high-level factors that will likely have a profound influence on TAD requirements and CONOPS, and hence on the TAD C2 architecture. The overall strategic thrust is regional—from peacemaking/keeping and humanitarian aid (OOTW) to MRCs. In this regional context, the United States will probably not act alone, but rather will join with allies and/or form ad hoc coalitions. Diminished forward presence will be necessitated by regional sensitivities and fiscal pressures.

The trends in this chart are not listed in any particular order of importance, but one strategic trend in particular deserves special mention: the proliferation of weapons of mass destruction (WMD). WMD is in many ways an unfortunate aggregation of very dissimilar threats (chemical/radiological, biological, and nuclear). The aggregation is unfortunate because the threats and responses to the individual WMD elements are likely to be quite different in their nature, scope, and significance. These differences could have profoundly different effects, not just on TAD operations, but on our entire force structure, power projection

strategy, and warfighting tactics. For example, chemical threats are relatively easy to deal with by various means as compared with biological and nuclear threats. Chemical weapons have been an important consideration since World War I. The chemical threat in Operation Desert Storm had very little effect on our operations (other than the nuisance of suiting up when Scuds were launched). On the other hand, even a handful of nuclear-armed Scuds would be another matter. We might even decide that these threats must be suppressed before we could deploy major force elements to the theater.

The point of these examples is to suggest that WMD, particularly biological and nuclear weapons, could have a *revolutionary* effect on warfighting. But the nation has yet to address this complex counterproliferation problem adequately—and we certainly cannot either in this briefing. But a caveat is in order: this briefing's evolutionary view of TAD as an overlay on "conventional" military operations may not be the appropriate paradigm in a future WMD threat environment. WMD may be a forcing function for revolutionary change - in fact, our commitment to TAD may be driven almost exclusively by emerging WMD threats. If so, a much broader consideration of TAD in the overall strategic context is certainly warranted.



TAD-Related Trends

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- **US Operations**
  - Increased naval littoral operations
  - Increased use of stealth techniques by friendly forces
  - Advent of new US/Allied shooter systems
  - Advent of persistent, UAV-based sensor systems

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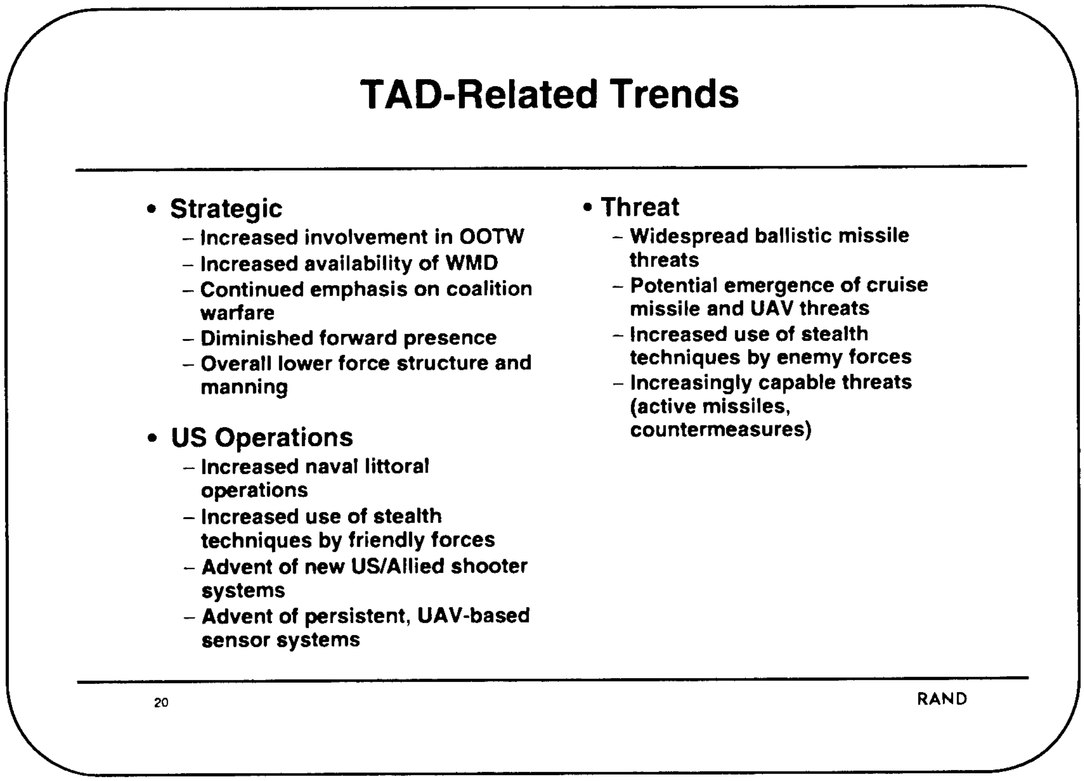
The trends in U.S. operations and systems outlined above will likely have a profound influence on TAD architectures and CONOPS, and hence on the TAD C2 architecture. Again, these trends are in no particular order. The increased significance of the Navy's littoral operations is natural given the global nature of our regional security concerns and decreasing day-to-day forward presence. Trends in precision strike, stealth, and persistent sensors will come together to enable decisive, high-intensity operations with minimal friendly casualties and acceptable collateral damage. Stand-off weapons and low-density battlefields will help to mitigate the threats posed to U.S. forces by enemy theater air and missile systems.



TAD-Related Trends

- Strategic
  - Increased involvement in OOTW
  - Increased availability of WMD
  - Continued emphasis on coalition warfare
  - Diminished forward presence
  - Overall lower force structure and manning
- US Operations
  - Increased naval littoral operations
  - Increased use of stealth techniques by friendly forces
  - Advent of new US/Allied shooter systems
  - Advent of persistent, UAV-based sensor systems
- Threat
  - Widespread ballistic missile threats
  - Potential emergence of cruise missile and UAV threats
  - Increased use of stealth techniques by enemy forces
  - Increasingly capable threats (active missiles, countermeasures)

The threat trends outlined above will likely have a profound influence on TAD requirements and CONOPS, and hence on the TAD C2 architecture.

Both quantitative and qualitative threat trends are listed above. At this level, the most significant threat trend (aside from WMD, which we discussed in a previous chart) is the development and deployment of land attack cruise missiles.

There is depth as well as breadth to our threat concerns. The depth concerns, which are not explicitly treated in this briefing, include what might be referred to as "responsive" countermeasures to future TAD CONOPS and systems (e.g., stealth). The threat world is not static—there will be a continuing action-reaction game played between the offense and defense. For our purposes, these threat considerations cannot be ignored, but our treatment of them must be superficial. Responsive threats could have a profound influence on TAD architectures and CONOPS. These detailed threat issues deserve much more careful consideration. For our purposes, however, it is sufficient to note that the effects would likely be

an (at this point unknown) shift in the relative significance of the four tasks and seven functions, with an uncertain impact on overall TAD system effectiveness, but the general TAD vision we develop here should remain relevant.

TAD-Related Trends

- Strategic
  - Increased involvement in OOTW
  - Increased availability of WMD
  - Continued emphasis on coalition warfare
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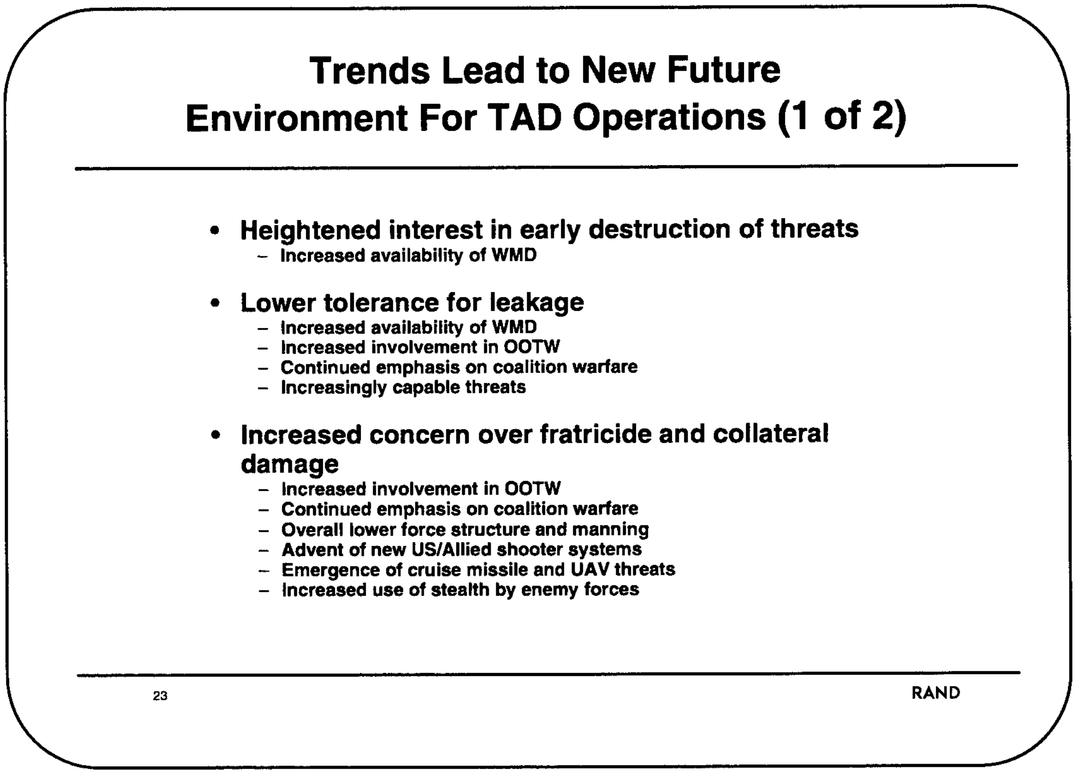
- Threat
  - Widespread ballistic missile threats
  - Potential emergence of cruise missile and UAV threats
  - Increased use of stealth techniques by enemy forces
  - Increasingly capable threats (active missiles, countermeasures)
- Technology
  - Advances in off-the-shelf processing and displays
  - Multiple means for secure, high-bandwidth comms

The technology trends outlined above will likely have a profound influence on TAD systems and CONOPS, and hence on the TAD C2 architecture. The two we focused on seem to have the greatest relevance. Others we identified but chose not to list include more speculative enhancements in sensors and sensor processing [e.g., Automatic Target Cueing/Automatic Target Recognition (ATC/ATR)], all-weather precision strike, and improvements in hard/buried target kill. These are important, but less so for TAD C2 than the likely advances in computers/displays and communications that have been forecast.



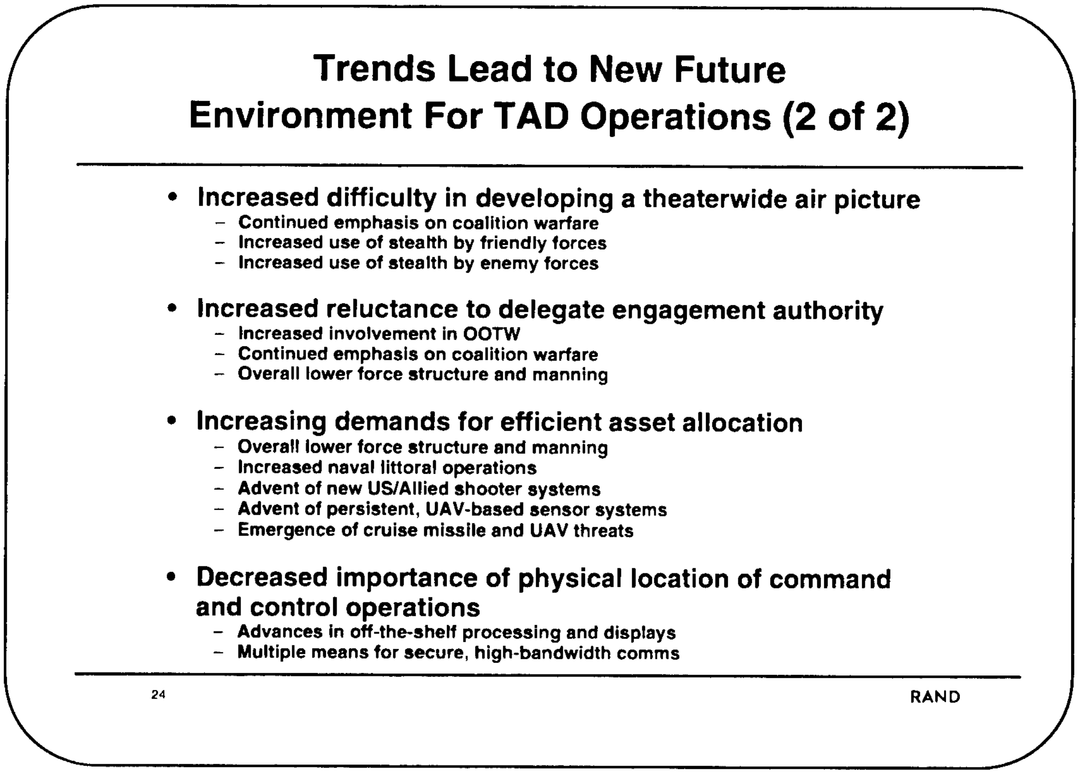
Trends Lead to New Future Environment For TAD Operations (1 of 2)

- **Heightened interest in early destruction of threats**
  - Increased availability of WMD
- **Lower tolerance for leakage**
  - Increased availability of WMD
  - Increased involvement in OOTW
  - Continued emphasis on coalition warfare
  - Increasingly capable threats
- **Increased concern over fratricide and collateral damage**
  - Increased involvement in OOTW
  - Continued emphasis on coalition warfare
  - Overall lower force structure and manning
  - Advent of new US/Allied shooter systems
  - Emergence of cruise missile and UAV threats
  - Increased use of stealth by enemy forces

Probably, as discussed earlier, the most significant challenge to future TAD systems will be the proliferation of WMD. It is likely that future TAD systems will be challenged to eliminate this WMD Sword of Damocles—the earlier, the better.

Increasingly, there is little tolerance for casualties of any sort, U.S., allied, or even enemy, especially in OOTW. There is consequently likely to be little tolerance for leakage. Unfortunately, as leakage tolerance decreases, increasingly sophisticated threats may increase the likelihood of leakage.

There is another side to the leakage issue that further stresses TAD systems. In our quest to eliminate leakage, we cannot cause unacceptable levels of collateral damage and fratricide. Identification, friend, foe or neutral (IFFN) is a serious challenge, particularly in integrated defenses against air-breathing threats.

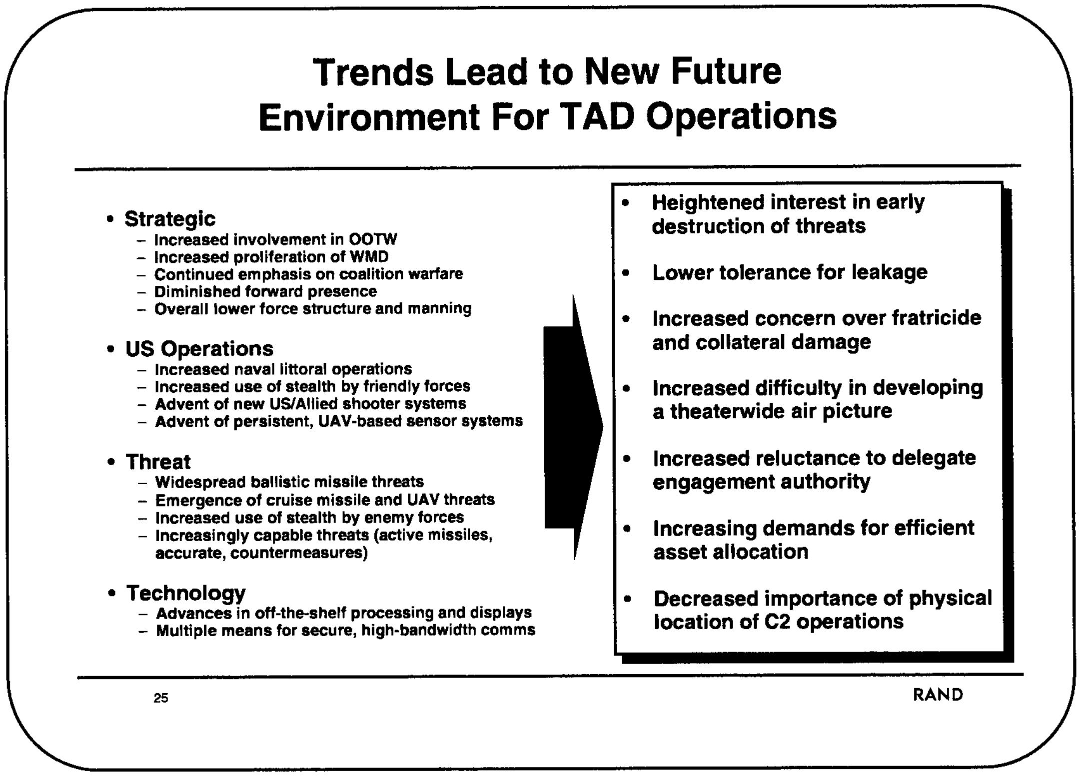


Trends Lead to New Future Environment For TAD Operations (2 of 2)

- **Increased difficulty in developing a theaterwide air picture**
  - Continued emphasis on coalition warfare
  - Increased use of stealth by friendly forces
  - Increased use of stealth by enemy forces
- **Increased reluctance to delegate engagement authority**
  - Increased involvement in OOTW
  - Continued emphasis on coalition warfare
  - Overall lower force structure and manning
- **Increasing demands for efficient asset allocation**
  - Overall lower force structure and manning
  - Increased naval littoral operations
  - Advent of new US/Allied shooter systems
  - Advent of persistent, UAV-based sensor systems
  - Emergence of cruise missile and UAV threats
- **Decreased importance of physical location of command and control operations**
  - Advances in off-the-shelf processing and displays
  - Multiple means for secure, high-bandwidth comms

The increasingly stressful requirements on the previous chart must be met despite the technical and operational challenges shown on the above chart. The development of a theaterwide air picture is made more difficult with the proliferation of increasingly stealthy platforms (U.S., allied, and enemy) in ad hoc coalition warfare (because of poor system interoperability and limitations in peacetime training and exercises). Reduced tolerance for mistakes will tend to increase the command level at which engagement decisions are made. Finally, it is likely that there will be increasing competition for limited TAD systems in this very stressful environment, which will increase demands for efficient TAD system allocation and operations.

Fortunately, there are information processing and communications advances that should enable us to better meet these challenges.



Trends Lead to New Future Environment For TAD Operations

- **Strategic**
  - Increased involvement in OOTW
  - Increased proliferation of WMD
  - Continued emphasis on coalition warfare
  - Diminished forward presence
  - Overall lower force structure and manning
- **US Operations**
  - Increased naval littoral operations
  - Increased use of stealth by friendly forces
  - Advent of new US/Allied shooter systems
  - Advent of persistent, UAV-based sensor systems
- **Threat**
  - Widespread ballistic missile threats
  - Emergence of cruise missile and UAV threats
  - Increased use of stealth by enemy forces
  - Increasingly capable threats (active missiles, accurate, countermeasures)
- **Technology**
  - Advances in off-the-shelf processing and displays
  - Multiple means for secure, high-bandwidth comms

- Heightened interest in early destruction of threats
- Lower tolerance for leakage
- Increased concern over fratricide and collateral damage
- Increased difficulty in developing a theaterwide air picture
- Increased reluctance to delegate engagement authority
- Increasing demands for efficient asset allocation
- Decreased importance of physical location of C2 operations

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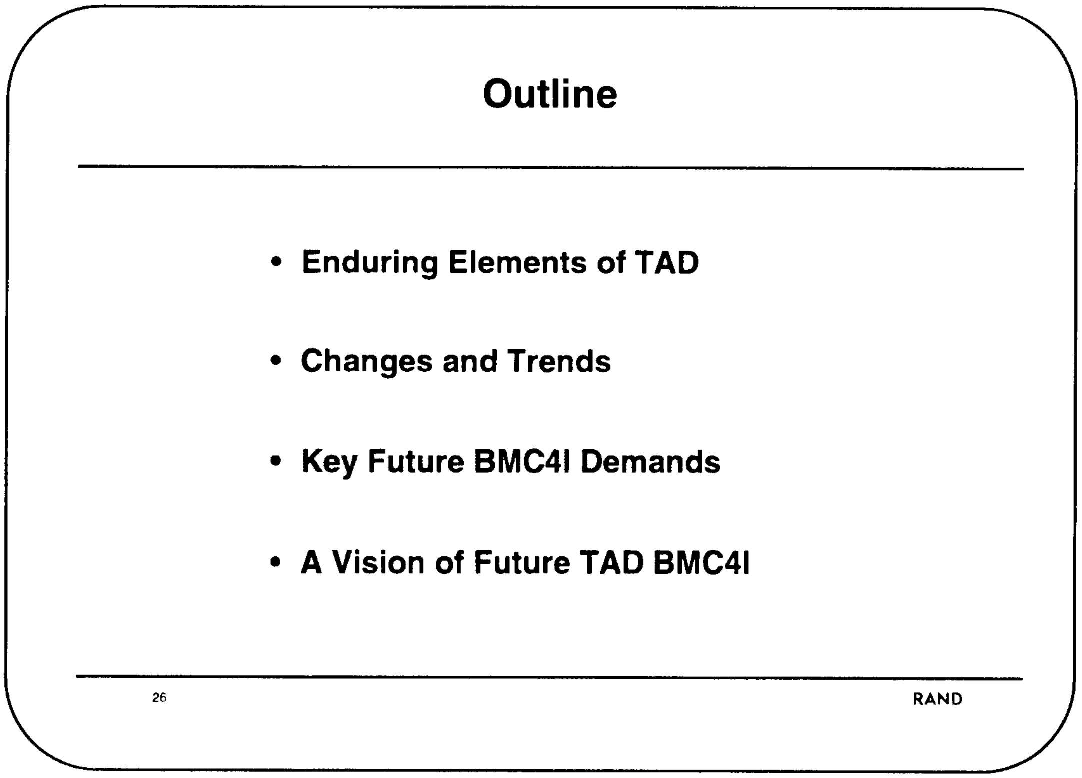
In summary, the general trends from the previous charts can be directly related to TAD-specific challenges and opportunities shown in the box on the right. These challenges and opportunities constitute a new future operating environment for theater air and missile defenses, one that will require new approaches and solutions.

A key feature of this future environment is the tension between centralization and decentralization of C2 functions. Resolving this issue will require balancing responses to the potentially conflicting factors in the box on the right.

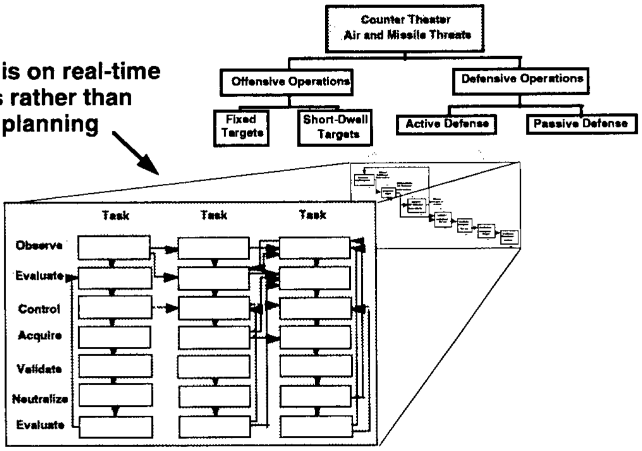


Outline

- Enduring Elements of TAD
- Changes and Trends
- Key Future BMC4I Demands
- A Vision of Future TAD BMC4I

We now turn to an assessment of how these trends in TAD requirements will influence future BMC4I demands and CONOPS.

Methodology for Characterizing TAD BMC4I Demands



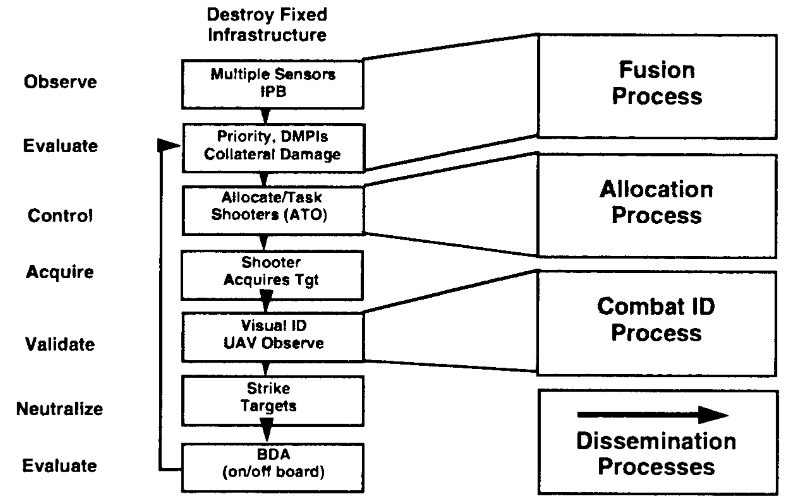
Emphasis is on real-time operations rather than deliberate planning

We have adopted a matrix methodology to derive and display future TAD BMC4I demands. The entries in the boxes of the matrix shown in the lower left above identify how the functions are performed to accomplish the tasks, and the interconnecting arrows show information flow.

In the next section of this briefing we will develop these matrices. As we do this, our emphasis will be on real-time operations and C2 versus deliberate planning and execution systems as exemplified by the current air tasking order (ATO) process. While the ATO process allows for some real-time flexibility (e.g., assigning aiarcraft to "kill boxes"), most of the ATO sorties are much more constrained. This real-time versus deliberate distinction is not strict (some matrices will allude to deliberate planning, particularly for attack operations against fixed infrastructure), but it reflects our judgments that:

1. Deliberate planning processes are well understood and executed—there will be evolutionary changes by 2010 but no major shift in vision.
2. The most stressing and increasingly important TAD C2 issues will be near-real-time; consequently, that is where we should focus our attention in this search for a 2010 vision.

An Example: Offensive Operations



	Destroy Fixed Infrastructure
Observe	Multiple Sensors IPB
Evaluate	Priority, DMPIs Collateral Damage
Control	Allocate/Task Shooters (ATO)
Acquire	Shooter Acquires Tgt
Validate	Visual ID UAV Observe
Neutralize	Strike Targets
Evaluate	BDA (on/off board)

Fusion Process

Allocation Process

Combat ID Process

Dissemination Processes

The chart above is an example of how the methodology will be applied. It was chosen because attack operations is a natural place to start and because the processes are rather well understood, although it has a more deliberate flavor than what will follow. The example introduces shorthand entries in the boxes, information flow arrows, and coding to distinguish between the four types of processes involved: (1) fusion, (2) allocation, (3) combat ID, and (4) dissemination.

We will walk through this example to interpret (and revise, as appropriate) the more detailed matrices that follow. Our words in and interpretations of these matrices should be considered a first-cut guide to help stimulate and focus the community's debate on these processes. At this point in their development, we believe they have value (i.e., the trends and first-order vision that results seem reasonable), but refinement is called for.

The task in this example is to destroy the fixed theater missile infrastructure (R&D, factories, garrisons, shelters, C3I, ...). The first key function is to **observe** the battlespace. This is sometimes referred to as "intelligence preparation of the battlefield" (IPB) and involves multiple

sensors and processing that may extend from normal peacetime collection through active hostilities. IPB answers questions such as: what is the enemy missile order-of-battle, how might he operate his forces, what signatures are associated with his systems, etc. The **evaluation** process then assigns target priorities, damage criterion, and weapon requirements (type, designated mean impact points (DMPIs), etc.). We have characterized the "observe and evaluate functions" as fusion processes; the key to success is effective merging of diverse data sources.

The **control** function in this example is really an allocation process; the ATO process captures these functions.

The shooters must then **acquire** their assigned targets, **validate** them (to minimize collateral damage and fratricide), and **neutralize** them by delivering ordnance. Finally, on- and off-board sensors gather information to **evaluate** bomb damage assessment (BDA), which feeds back into the evaluation task.

Ensuring the Effectiveness of Future TAD Offensive Operations

Key Elements of the Future TAD Environment

- Heightened interest in early destruction of threats
- Lower tolerance for leakage
- Increased concern over fratricide and collateral damage
- Decreased importance of physical location of C2 operations

- Heightened importance of offensive operations
- Key BMC4I questions:
  - How will information be fused to enable effective offensive TAD operations?
  - How will multiple, specialized TAD sensors and shooters be allocated in real time?

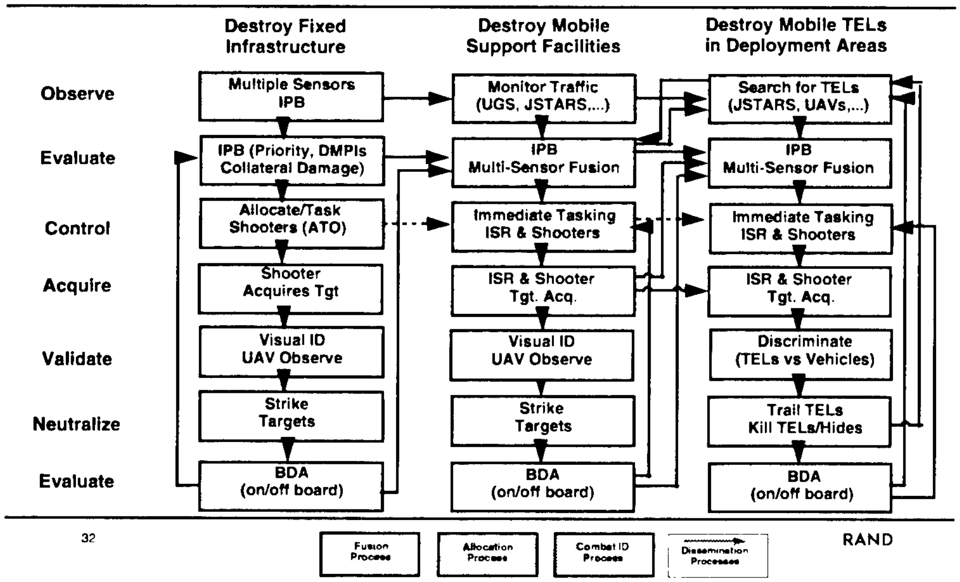
Offensive operations will become increasingly important because of the environmental forcing functions identified in the box on the left. And, improvements in secure communications and processing [e.g., Joint Tactical Information Distribution System (JTIDS)] will give us increasing flexibility over the "how and where" of C2 for these offensive operations.

The analysis of TAD BMC4I to support offensive operations, as described in the two charts to follow, center on fusion and allocation. Fusion will be increasingly critical in TAD offensive operations to exploit all information sources to find hidden and/or mobile targets. It is obvious that the more information that can be used in any TAD operation, the better. But, beyond this truism, there are less obvious cases in which fusion is not only valuable but essential.

Allocation concerns reflect the emergence and proliferation of specialized sensor platforms such as UAVs which, as with the Joint Surveillance Target Attack Radar System (JSTARS) in the Gulf War, may serve multiple masters and needs (e.g., intelligence, reconnaissance, surveillance, targeting, BDA). TAD offensive operations themselves will

involve critical sensor allocation decisions (e.g., area coverage, response to cueing, search and ID, etc.). How will these allocation decisions, many likely to require real-time action, be managed?

Offensive Operations: Pre-Launch Attacks



	Destroy Fixed Infrastructure	Destroy Mobile Support Facilities	Destroy Mobile TELs in Deployment Areas
Observe	Multiple Sensors IPB	Monitor Traffic (UGS, JSTARS,...)	Search for TELs (JSTARS, UAVs,...)
Evaluate	IPB (Priority, DMPIs Collateral Damage)	IPB Multi-Sensor Fusion	IPB Multi-Sensor Fusion
Control	Allocate/Task Shooters (ATO)	Immediate Tasking ISR & Shooters	Immediate Tasking ISR & Shooters
Acquire	Shooter Acquires Tgt	ISR & Shooter Tgt. Acq.	ISR & Shooter Tgt. Acq.
Validate	Visual ID UAV Observe	Visual ID UAV Observe	Discriminate (TELs vs Vehicles)
Neutralize	Strike Targets	Strike Targets	Trail TELs Kill TELs/Hides
Evaluate	BDA (on/off board)	BDA (on/off board)	BDA (on/off board)

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The objective of pre-launch offensive operations (also called attack operations) is to deny the enemy the ability to launch missiles and aircraft. The tasks to accomplish this objective are typically divided into the three shown across the top of this chart. This task breakdown is useful because although the tasks are interrelated, they have distinct systems and operational elements. The first task is to destroy the fixed infrastructure, including R&D and production facilities, garrisons, airfields and fixed launchers, and command and control facilities. Attacks on these targets will cap the threat and reduce sortie/salvo rates. The next task is to destroy the mobile support systems deployed to the field. These missile-related targets include maintenance, fueling and resupply vehicles, reload missiles and warheads, crews, command and control vehicles, and transporter, erector, launchers (TELs) in their field hides. For manned aircraft threats, these targets are associated with operations from austere dispersal airfields (e.g., grass fields, highways). The final pre-launch attack operations task is to kill mobile "short dwell" targets such as TELs and cruise missile launchers as they are exposed just prior to launch.

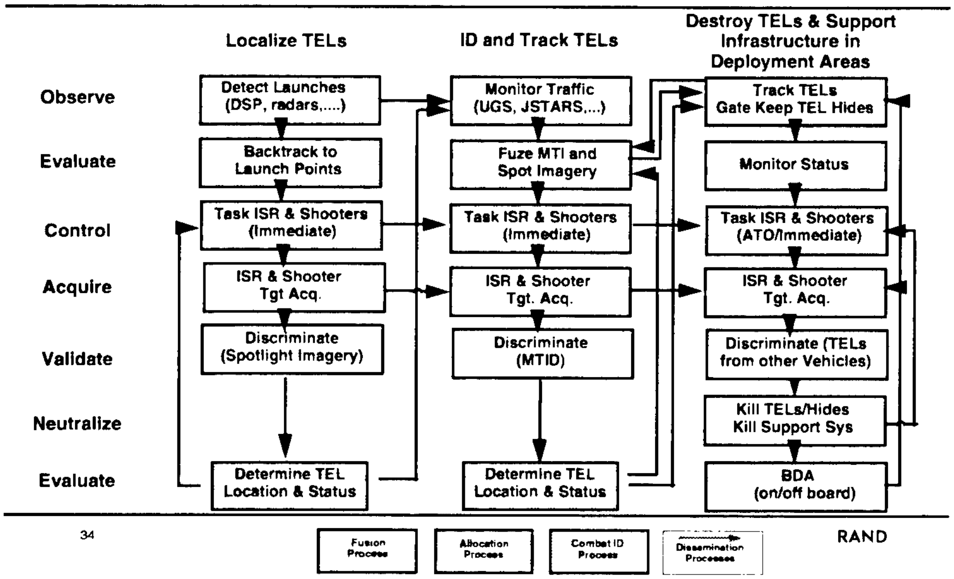
There is a natural order to these tasks. Intelligence preparation of the battlefield (IPB) is shorthand for all the pre-war intelligence collection and analyses to assess the nature of the threat and identify targets. In addition to characterizing the fixed infrastructure and enemy order-of-battle, IPB attempts to assess the enemy's strategy and doctrine and operational concepts, which are useful in focusing the search for mobile systems deployed into the field.

Fixed TAD targets are prioritized and targeted just as are other strategic targets. Facilities such as WMD production and storage sites have a high priority, while less immediate threats such as R&D facilities have a lower priority. Attack plans are generated in the ATO and executed by the Service components.

Once the enemy has dispersed to field hides, the task becomes one of "seek and destroy." The seeking part observes the deployment areas to look for traffic patterns and other clues that can help localize, detect, identify, and keep track of the mobile systems. Since the sensors that can help provide this information are multi-mission (e.g., JSTARS), there are sensor allocation processes to be resolved. The various intelligence and surveillance sources must be combined with models of the enemy's operations and clutter sources (e.g., commercial road traffic, other military maneuvers) to find likely targets. This is a boot-strap process that requires fusion and analysis of the multi-spectral sources to increase the probability of target detection while simultaneously minimizing false alarms that waste time and resources. Wide-area sensors develop contacts that must be refined by higher-resolution spotlight sensors that support the tasking of shooters. The shooters must then acquire the targets and deliver their weapons, often with tight time constraints. These shooters will be tasked in the ATO but their specific mobile targets will be developed during their mission and will be executed via "immediate" redirection.

The attacks are conducted according to the rules-of-engagement, which might, for example, require the pilots to positively identify the targets based on their own sensors (rather than attacking coordinates). Finally, the results of these strikes are assessed and follow-up actions are planned. Timely BDA is both difficult and important. The BDA from pilot reports and gun camera records usually is augmented with independent off-board sources.

Offensive Operations: Post-Launch Attacks



	Localize TELs	ID and Track TELs	Destroy TELs & Support Infrastructure in Deployment Areas
Observe	Detect Launches (DSP, radars,....)	Monitor Traffic (UGS, JSTARS,....)	Track TELs Gate Keep TEL Hides
Evaluate	Backtrack to Launch Points	Fuze MTI and Spot Imagery	Monitor Status
Control	Task ISR & Shooters (Immediate)	Task ISR & Shooters (Immediate)	Task ISR & Shooters (ATO/Immediate)
Acquire	ISR & Shooter Tgt Acq.	ISR & Shooter Tgt. Acq.	ISR & Shooter Tgt. Acq.
Validate	Discriminate (Spotlight Imagery)	Discriminate (MTID)	Discriminate (TELs from other Vehicles)
Neutralize			Kill TELs/Hides Kill Support Sys
Evaluate	Determine TEL Location & Status	Determine TEL Location & Status	BDA (on/off board)

Fusion Process
Allocation Process
Combat ID Process
Dissemination Processes

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Post-launch attack operations are treated as a separate case from pre-launch attack operations for ballistic missile threats for one very compelling reason: The missile launch signature is promptly and unequivocally detected by wide-area sensors such as the Defense Support Program (DSP). TELs may get lost in hides or ground clutter, but missile launches stand out clearly. Therefore, missile launches can be used to focus attack operations. The problem, of course, is that the missile launches that start this process have been successful; they were not denied by pre-launch attack operations. These successful launches become a problem for the active and passive defenses. Post-launch attack operations attempt to limit subsequent launches by using IPB data and surveillance data fused with the known launch points to allocate sensors and shooters in near-real time to find and track the TELs, reload missiles, and other support equipment in the field. These can then be attacked and destroyed at a time of our choosing.

The first real-time task is to localize the TEL that just launched the missile by backtracking the launch track to the launch point. Sensors and/or shooters can then be directed to the launch area to detect and identify the

TEL. The ability to do this depends on how quickly the area can be searched and whether or not the TEL is moving or has reached a hide that the sensors cannot penetrate. Since the TEL will attempt to flee the launch site and hide from searchers, time is of the essence, which means sensors and shooters have to be tasked quickly and respond in minutes.

Once a TEL has been found, the decision has to be made to attack it immediately or to attempt to follow it to its hide or resupply point, which could provide more lucrative targets (e.g., stores of reload missiles and warheads). This decision will depend on an assessment of the risks of losing track of the TEL in transit.

Once the TEL reaches a hide or resupply cache, the site can be monitored in the hopes that traffic patterns will reveal even more lucrative targets. If monitoring detects that reloaded TELs are about to launch, then presumably these TELs would be attacked (resulting in a pre-launch kill enabled by post-launch attack operations).

As TELs are attritted, the enemy's launch rate will decline until all the TELs have been killed or disabled. At this point, all unfired missiles are grounded—their launches have been denied by post-launch attack operations.

Ensuring the Effectiveness of Future TAD Active Defense Operations

- Lower tolerance for leakage
- Increased concern over fratricide and collateral damage
- Increased difficulty in developing a theaterwide air picture
- Increased reluctance to delegate engagement authority
- Increasing demands for efficient asset allocation
- Decreased importance of physical location of C2 operations

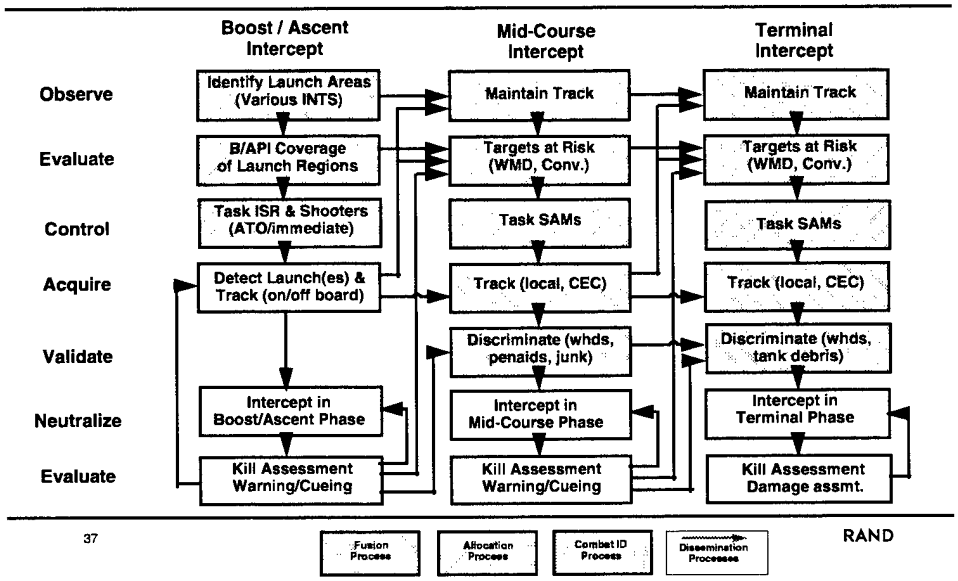
- **Heightened need for coordinated, efficient allocation of defense assets**
- **Key BMC4I questions:**
  - **How will a real-time fused theater air picture be created?**
  - **How will efficient allocation of area air defense assets be accomplished?**
  - **What technical approaches will be used to provide effective combat ID information?**

The factors in the box on the left summarize both the need for and opportunities to enhance active air and missile defense operations. The key BMC4I questions that must be addressed, listed on the right, will be further developed in the matrices in the next two charts.

In thinking about the emerging threat environment and U.S./coalition TAD operations and systems, it is clear that both the need and opportunity exist for much better situational awareness at all command levels. A key element is the real-time air picture, which should be able to show the ID, status, and track for all aerospace objects, IFFN. This air picture, if feasible, will also go a long way toward solving the pressing combat ID (IFFN) problems that limit defense effectiveness.

Finally, with a proliferation of threats and defense assets (some of which, such as interceptor aircraft and surface-to-air missiles (SAMs), are multi-mission capable), allocation issues, including real-time direction, must be addressed.

Defensive Operations: Intercept of Ballistic Threats



	Boost / Ascent Intercept	Mid-Course Intercept	Terminal Intercept
Observe	Identify Launch Areas (Various INTS)	Maintain Track	Maintain Track
Evaluate	B/API Coverage of Launch Regions	Targets at Risk (WMD, Conv.)	Targets at Risk (WMD, Conv.)
Control	Task ISR & Shooters (ATO/immediate)	Task SAMs	Task SAMs
Acquire	Detect Launch(es) & Track (on/off board)	Track (local, CEC)	Track (local, CEC)
Validate		Discriminate (whds, penaids, junk)	Discriminate (whds, tank debris)
Neutralize	Intercept in Boost/Ascent Phase	Intercept in Mid-Course Phase	Intercept in Terminal Phase
Evaluate	Kill Assessment Warning/Cueing	Kill Assessment Warning/Cueing	Kill Assessment Damage assmt.

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Those ballistic missiles that are successfully launched despite aggressive offensive actions must be negated by the combined effects of active and passive defenses. There are three distinct ballistic missile flight regimes in which intercept can occur. Boost/ascent phase intercept occurs in early flight while the motor is burning or shortly after burnout but before payload deployment. Midcourse intercept occurs during the missile's ballistic flight in the near vacuum of space. Finally, terminal intercept occurs as the missile passes back through the atmosphere as it approaches its target.

The earlier the defense can get a shot at a threat missile the better. If early shots miss, the defense might have time and battlespace for another shot. If the defense destroys the missile during boost, the debris will fall short of its target and fractionated payloads will not saturate later defense layers. Of course, missiles or lasers capable of destroying a missile in its first minute or two of flight have to be near the launch point, which could be deep in enemy territory. Thus, the defense must increase its intercept range, and hence stand-off potential, or it must be able to operate over hostile territory (e.g., after air supremacy has been achieved). Midcourse

intercept involves predictable flight dynamics (Kepler) and the best operating environment for infrared hit-to-kill sensors, but the potential to deploy credible exo-penaids (penetration aids) may give the offense the advantage over the defense in midcourse. Finally, the terminal defenses must operate within the atmosphere, which exacerbates some problems (e.g., sensor window heating) and mitigates others (e.g., simple exo-penaids that cannot survive reentry). And, of course, if the terminal defenses miss, passive defenses are the last hope to limit damage.

Boost/ascent-phase intercept platforms will benefit from as much IPB as possible. If, through fusion of multiple sources, the enemy's launch areas can be localized, the defense platforms can be deployed to maximize their intercept potential while minimizing risks to the defense platforms. The boost/ascent defense system may have separate platforms for sensors and shooters or the sensors and intercept systems may be integrated on relatively autonomous platforms (e.g., long endurance UAVs). Kill assessment should not be too difficult and will be performed by the defense.

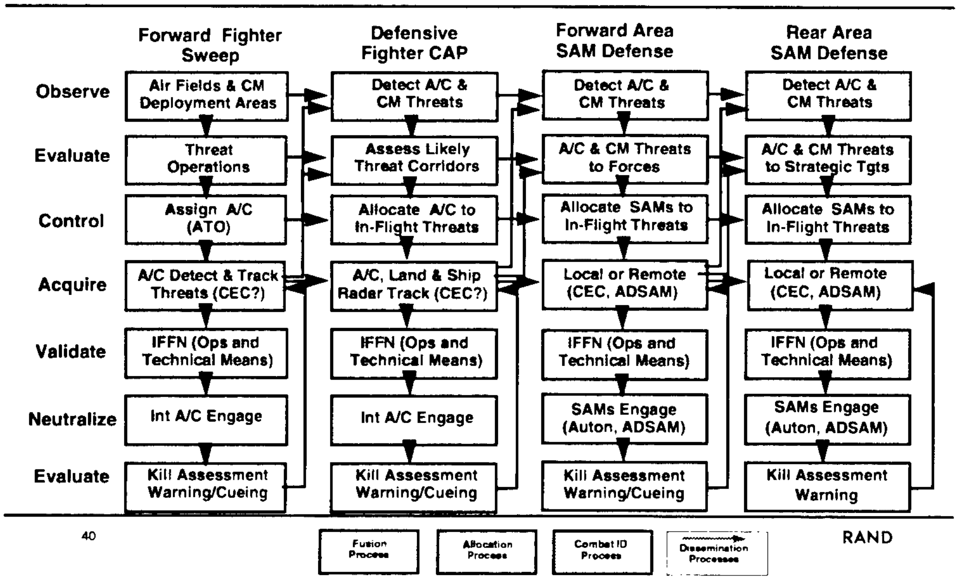
Because the next phase of a threat missile's flight is midcourse, the midcourse defenses should receive cueing information from the boost/ascent system (if any) and/or launch detection systems such as DSP. Cueing will extend the defense's battlespace by letting its search radars acquire the threats earlier. The most worrisome midcourse defense issue is discrimination—which object is the warhead? The discrimination problem can be exacerbated by the offense (through use of decoys, jammers, or fragmented tanks) and the boost/ascent phase defense (imperfect kill assessment and debris from ascent-phase engagements). If multiple systems have overlapping footprints, they must be allocated specific threats to negate.

Finally, the results of these upper-tier engagements filter down to the terminal defenses. Again, the terminal systems benefit from cueing and threat thinning by the earlier defense activities, and, fortunately, the atmosphere will likely strip out much of the debris and simple penaids, so that the warheads will be less difficult to discriminate from other junk reentering in the threat cloud.

In each defense regime, there is a theoretical benefit from engaging the threats in a sequential shoot-look-shoot tactic rather than a salvo of

interceptors if there is both time and kill assessment potential. The benefit is not reduced leakage for an individual threat missile, but rather reduced interceptor expenditures, which could be significant if saturation threats are a concern.

Defensive Operations: Intercept of Airbreathing Threats



	Forward Fighter Sweep	Defensive Fighter CAP	Forward Area SAM Defense	Rear Area SAM Defense
Observe	Air Fields & CM Deployment Areas	Detect A/C & CM Threats	Detect A/C & CM Threats	Detect A/C & CM Threats
Evaluate	Threat Operations	Assess Likely Threat Corridors	A/C & CM Threats to Forces	A/C & CM Threats to Strategic Tgts
Control	Assign A/C (ATO)	Allocate A/C to In-Flight Threats	Allocate SAMs to In-Flight Threats	Allocate SAMs to In-Flight Threats
Acquire	A/C Detect & Track Threats (CEC?)	A/C, Land & Ship Radar Track (CEC?)	Local or Remote (CEC, ADSAM)	Local or Remote (CEC, ADSAM)
Validate	IFFN (Ops and Technical Means)	IFFN (Ops and Technical Means)	IFFN (Ops and Technical Means)	IFFN (Ops and Technical Means)
Neutralize	Int A/C Engage	Int A/C Engage	SAMs Engage (Auton, ADSAM)	SAMs Engage (Auton, ADSAM)
Evaluate	Kill Assessment Warning/Cueing	Kill Assessment Warning/Cueing	Kill Assessment Warning/Cueing	Kill Assessment Warning

As with defenses against ballistic missiles, defenses against manned aircraft and cruise missiles start forward over enemy territory and have distinct intercept regimes as the threats approach their targets. The current emphasis on forward fighter sweeps reflects the superiority of U.S. equipment and pilots: if the enemy flies, he dies, often very near the airfield he just took off from. Defensive counterair (DCA) is a holdover from NATO/Warsaw Pact scenarios in which defensive barriers of combat air patrol (CAP) interceptor aircraft were planned to blunt massive raids of Warsaw Pact aircraft. Forward area air defenses are mobile SAMs and anti-air artillery (AAA) that are deployed with the maneuver groups to protect the troops. These defenses are predominantly shoulder-fired SAMs and short-range vehicle-mounted missiles and guns such as Avenger. The rear area defenses are longer-range SAMs such as Patriot, Hawk, and Aegis/ Standard Missile. These are deployed to protect specific target areas such as ports, airfields, depots, garrisons, and cities.

Forward fighter sweeps are conducted against known threat corridors associated with airfields and cruise missile deployment areas. The IPB identifies these areas and the enemy's air order-of-battle. The fighters are

typically vectored to threat aircraft and missiles by surveillance platforms such as the Airborne Warning and Control System (AWACS). Intercepts follow the rules of engagement. IFFN is performed by cooperative (e.g., transponders) and noncooperative (e.g., radar signature) means.

Defensive counterair operations are similar, but are conducted as a barrier operation rather than a sweep.

Forward area air defenses are the ground-based air defenses that protect front-line troops. Fortunately, fixed-wing manned aircraft threats are expected to be suppressed by the forward air operations, but future threats could change this (e.g., stealthy cruise missiles). Additionally, the ground forces must be concerned with rotary-wing air threats that interceptor aircraft cannot effectively suppress.

Because there are friendly aircraft transiting to and from their rear airfields and enemy territory, there is a fratricide concern associated with forward area defenses. Typically, these concerns are addressed by airspace controls and restrictive rules of engagement—e.g., visual ID by Stinger crews.

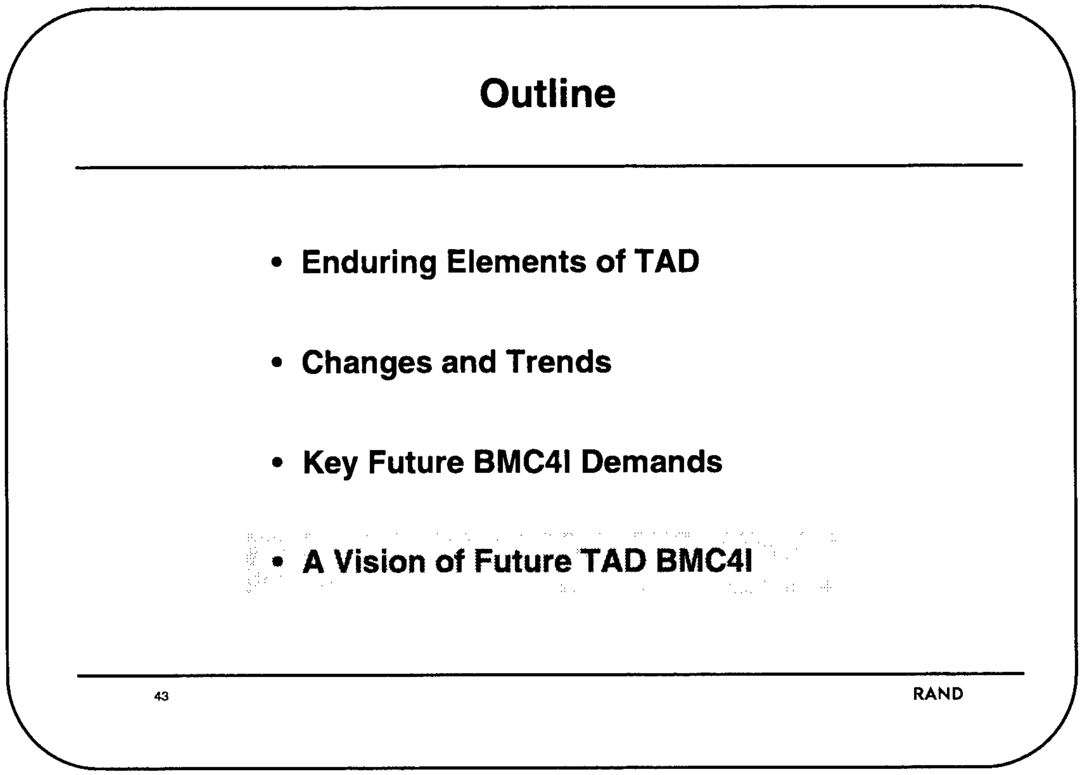
The rear area defenses have similar fratricide issues and mechanisms to deal with them. As emerging threats such as stealthy land attack cruise missiles emerge, the IFFN and SAM effectiveness issues will be addressed by improved situational awareness provided by cooperative engagement capability (CEC)-like systems.

Ensuring Effective Operational Control of Future TAD Forces

- Increased concern over fratricide and collateral damage
- Increased reluctance to delegate engagement authority
- Increasing demands for efficient asset allocation
- Decreased importance of physical location of C2 operations

- **Heightened need for flexible operational C2 solutions**
- **Key BMC4I questions:**
  - What processes will be used to provide engagement authority?
  - Do command centers require new/additional classes of information and decision aids?
  - How will this information be disseminated?

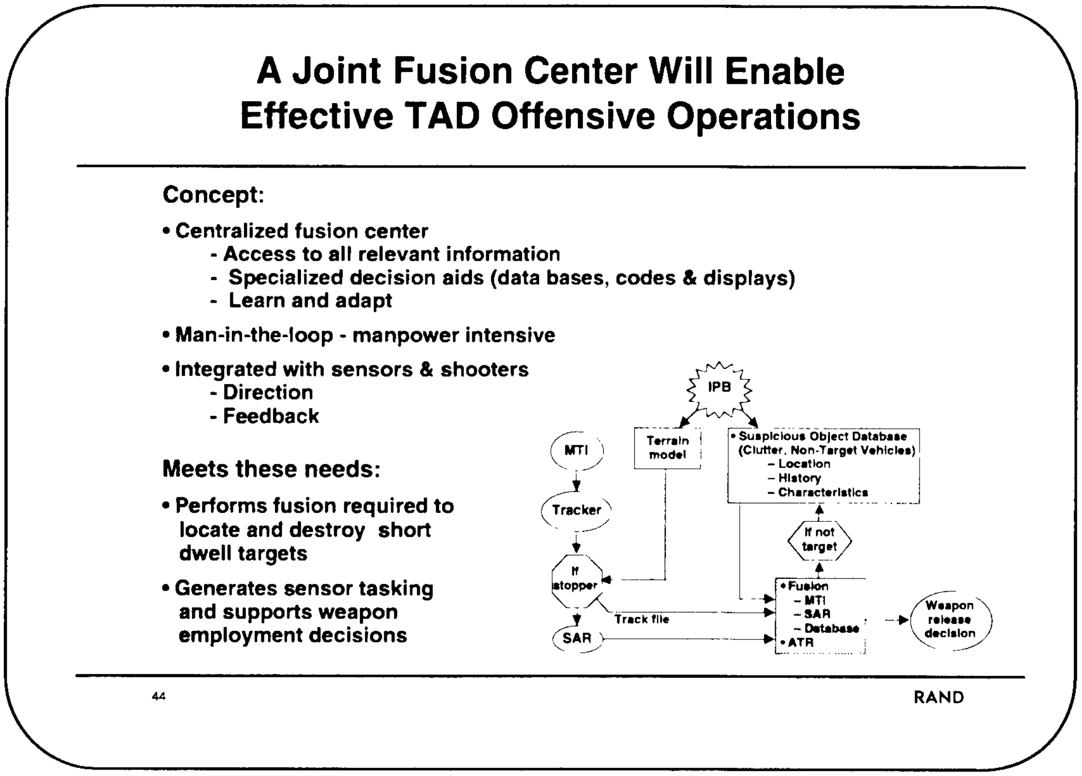
Finally, for the reasons listed in the box, we believe there will be a heightened need for more flexible TAD operational C2 solutions in the future. The tight, real-time control of air operations exercised by the Combined Air Operations Center (CAOC) in Aviano, Italy, for operations over Bosnia are just one example of OOTW that may increasingly stress C2 capabilities. As the technology allows ever greater centralized control, operations will be rapidly adapted to unique circumstances. How can this type of operational flexibility best be incorporated in TAD operations circa 2010?



Outline

- Enduring Elements of TAD
- Changes and Trends
- Key Future BMC4I Demands
- A Vision of Future TAD BMC4I

In the next few charts we'll outline our 2010 TAD vision, derived by organizing and prioritizing the preceding materials. The vision is just that: it is our view of the future. Those who may approach the problem from a different perspective may see things differently. Our hope, however, is that the thought process and methodology behind our vision will be helpful in advancing reasonable TAD solutions to accepted strategic and tactical goals. The linkage between goals and objectives and TAD CONOPS and BMC4I systems may be the principal value of this work. This vision is, at best, a beginning, but it does provide a framework for addressing contemporary issues such as the proper role for CEC-like systems, cruise missile threat implications, and balanced TAD architectures to address emerging WMD problems.



A Joint Fusion Center Will Enable Effective TAD Offensive Operations

Concept:

- Centralized fusion center
  - Access to all relevant information
  - Specialized decision aids (data bases, codes & displays)
  - Learn and adapt
- Man-in-the-loop - manpower intensive
- Integrated with sensors & shooters
  - Direction
  - Feedback

Meets these needs:

- Performs fusion required to locate and destroy short dwell targets
- Generates sensor tasking and supports weapon employment decisions

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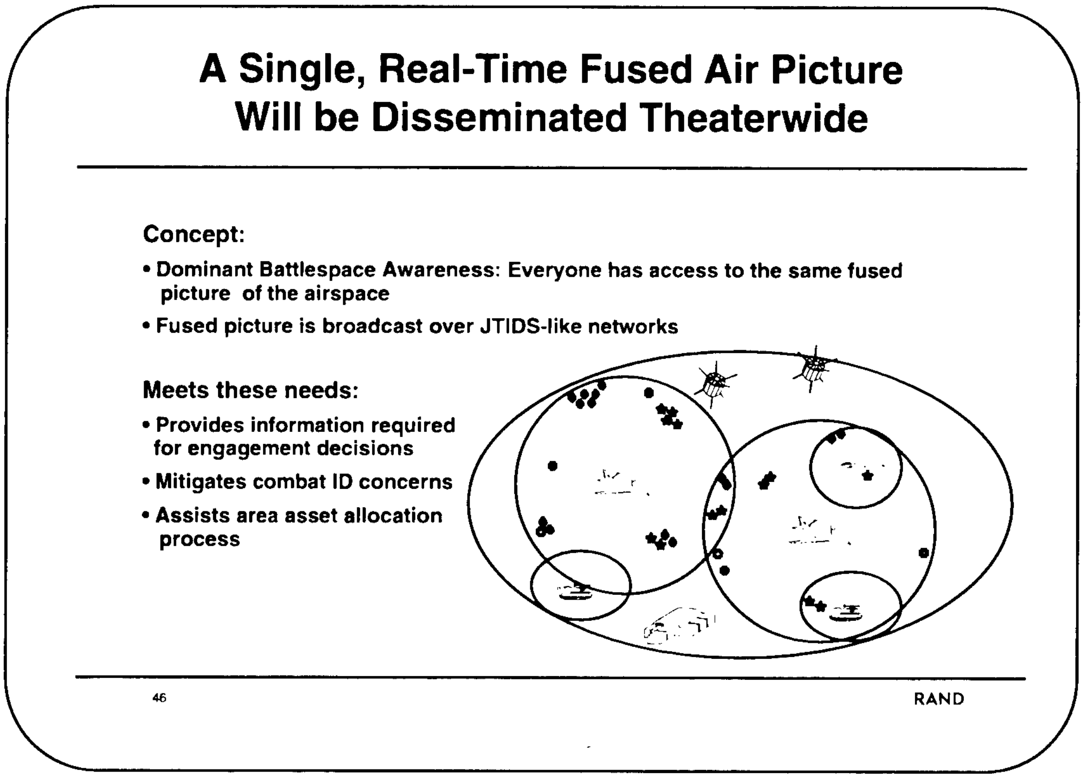
In our 2010 TAD vision, there will be a centralized joint fusion center to enable much more effective offensive operations against short dwell threats such as missile TELs. We envision a highly centralized, manpower-intensive facility (location may be unimportant). Its purpose will be to take *all* relevant information and provide a threat picture to other decisionmakers who will allocate and direct sensors and shooters (which will provide additional data for the fusion center). A centralized, manpower-intensive facility appears necessary to exploit the synergistic and serendipitous nature of successful fusion activities—no purely computational function will meet TAD needs by 2010.

The diagram in the lower right illustrates a fusion concept using moving target indicator (MTI) radars and synthetic aperture radars (SAR) for target imaging. The concept, of course, applies to other imaging sensors as well. IPB, MTI, and SAR data are fused. As usually defined, IPB prepares databases describing fixed targets, terrain, backgrounds, road networks, and so on. We include the development, prior to the conflict, of a "suspicious object" database. Natural clutter and nontarget vehicles that appear to be similar to TELs are scrutinized, to the extent possible, at high

resolution from multiple aspects and with multi-spectral sensors. Pertinent assessment information, such as location, history, and signature characteristics, is recorded for each object.

After the conflict begins, MTI radars attempt to track all moving vehicles in the suspected operating area and to determine when a vehicle stops. Terrain data are used to help distinguish between a vehicle stopping and a track dropout resulting from a line-of-sight blockage. When a vehicle stop is declared, a high-resolution SAR images the area. The SAR data, the vehicle's track file, and information from the suspicious object database are fused in an automatic target recognition (ATR) process. If the object passes the ATR, it is passed to a weapon-release authority. If not, its information is added to the suspicious object database.



A Single, Real-Time Fused Air Picture Will be Disseminated Theaterwide

Concept:

- Dominant Battlespace Awareness: Everyone has access to the same fused picture of the airspace
- Fused picture is broadcast over JTIDS-like networks

Meets these needs:

- Provides information required for engagement decisions
- Mitigates combat ID concerns
- Assists area asset allocation process

Our 2010 vision includes a single, real-time fused air picture that all force elements can access and update. The idea is simple and appealing. The detailed implementation, of course, may not be so simple. The potential value is obvious, but why do we believe it is a reasonable vision for as early as 2010?

The answer is that a full suite of enabling technologies is maturing. These technologies and systems include: the Global Positioning System (GPS); global broadcast system; JTIDS; CEC; computers, track algorithms, and displays; and low probability of intercept (LPI) satellite communications. Although we mention CEC, the air picture we envision would not necessarily contain fire-control quality data (except possibly in local subnets).

The pieces will exist in 2010; the issue is, can we use them to develop an affordable and robust air picture architecture?

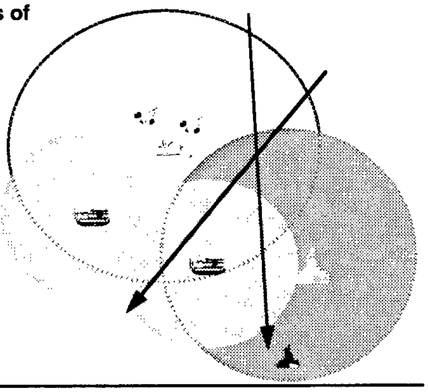
A Centralized Joint Allocation Function Will Enable Real-Time Allocation of Active Defense Assets

Concept

- Cross-service allocation of area defense assets to optimally meet threats
- Minimize rule and geography based methods of engagement control
- Implemented at any command level

Meets these needs:

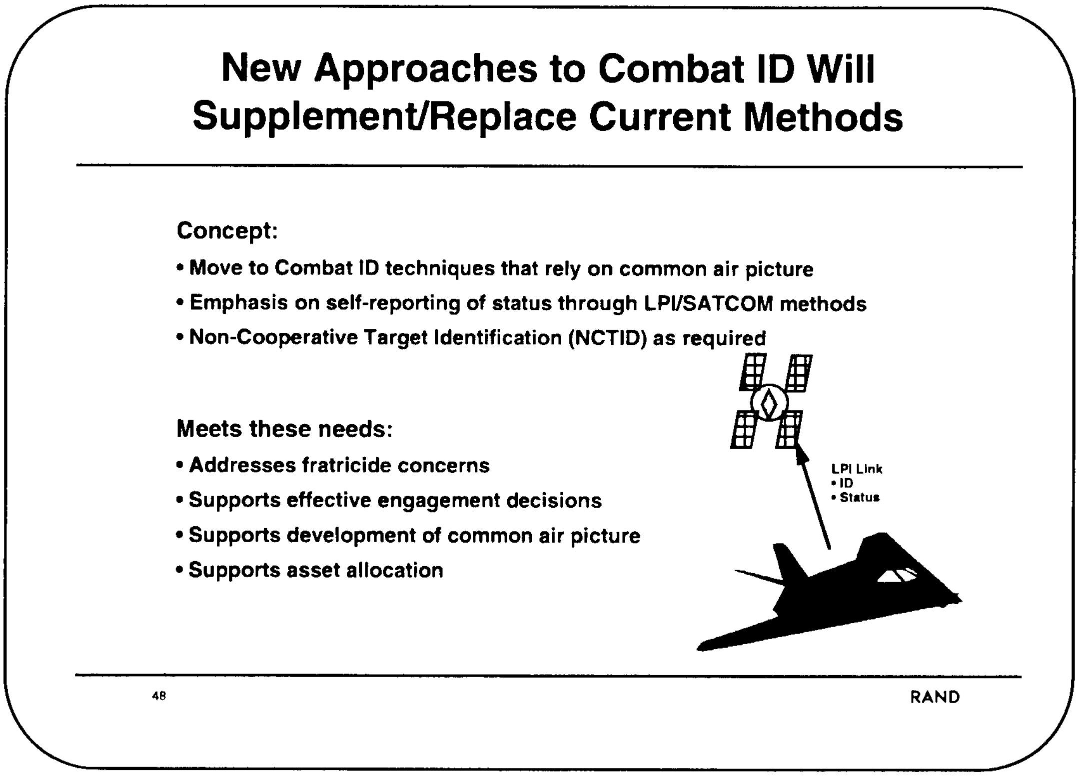
- Efficiently allocates sensors & shooters
- Minimizes leakage
    - Preferential
    - Robust
- Enables expanded battlespace - early intercepts



The 2010 vision on the above chart is of a truly integrated joint air and missile defense operation. Defense assets would be allocated optimally from the theater commander's perspective and real-time engagement control would minimize leakage against uncertain threat objectives and tactics. Appropriate command levels would automatically be tasked and enabled depending on the threat and (possibly changing) defense missions and priorities (e.g., preferential defenses).

This vision can be thought of as "super CEC-like." Note that we're not talking about CEC per se (which is a specific hardware and software system), but rather a *situation* in which every platform contributes to the maximum theoretical extent possible in a synergistic blend of information and control with all other platforms. Each defense system has the information it can use from all other sources and the integrated set of defense systems can engage threats optimally from the integrated (vice autonomous) perspective. This will maximize battle space and engagement opportunities (shots), and minimize leakage and interceptor expenditures.

As an example of what might happen under attack, an Aegis ship might focus its defenses against threats to land targets while land-based defenses simultaneously provide the first line of defense for the naval battle group.



New Approaches to Combat ID Will Supplement/Replace Current Methods

Concept:

- **Move to Combat ID techniques that rely on common air picture**
- **Emphasis on self-reporting of status through LPI/SATCOM methods**
- **Non-Cooperative Target Identification (NCTID) as required**

Meets these needs:

- **Addresses fratricide concerns**
- **Supports effective engagement decisions**
- **Supports development of common air picture**
- **Supports asset allocation**

The above element of the 2010 vision is critical for addressing the local IFFN problem and the global air picture problem. LPI communications links through satellites, when coupled with GPS position data, ought to enable the United States to keep accurate track of all U.S. aircraft, even stealthy ones.

Information Access and Dissemination Issues *Should Not* Limit C2 Operations

Concept:

- **Multiple options will be available to selectively provide information to command centers and platforms**
- **Evolutionary Global Command and Control System (GCCS)-based planning info at all command centers**
- **Evolutionary JTIDS-based data selectively available on all platforms and command centers (shared air picture)**
- **Limited number of platforms and command centers with CEC-like track information**

Meets these needs:

- **Enables effective delegation of engagement authority**
- **Enables shared air picture**
- **Enables allocation functions**
- **Enables fusion functions**

The elements of this vision *should not* be constrained by communications links. In 2010 (and 2003), technology will support multiple means of encrypted, high-bandwidth communications in most conceivable theaters, enabling tailorable "on-demand," relatively robust (e.g., some jamming resistance via multiple pathways) communications systems for most needs for major backbone communications (e.g., CONUS to/from the theater) given reasonable prior planning and investments. Unfortunately, while the technology will support almost any conceivable communications need, including bulk military requirements, budgetary pressures may continue to be limiting (e.g., slow insertion of robust tactical communications such as JTIDS with sufficient bandwidth is worrisome).

Final Thoughts and Caveats

- **This vision deals with the major issues facing future TAD BMC4I**
  - Fusion, Allocation, Combat ID, Dissemination
- **However, this vision is strongly evolutionary in nature**
  - Can be viewed as the logical extension of current efforts
  - Are more revolutionary visions feasible?
- **This vision also assumes that TAD operations maintain a consistent relationship to the theater campaign**
  - Will WMD cause changes in power projection doctrine and strategy?
  - Will allocation of dollars shift between TAD and other force elements?

We have focused our vision on the few critical issues facing future TAD BMC4I. We have attempted to support this particular focus with a strategies-to-tasks and process assessment consistent with general technology trends (as opposed to specific systems concepts).

However, we recognize that our vision is evolutionary, even "conventional," in its assumptions, scope, and analytic approach. We believe this is appropriate but we also recognize that there are threat forces (e.g., WMD) that could force much more revolutionary changes in the way the United States conducts military operations, including theater air defense.

This brings us to the final caveat on the above chart: The vision we developed has implicit assumptions about the future force mix and investment levels in TAD relative to other force elements. As a U.S. national strategy for countering the proliferation of WMD is developed, the force structure assumptions could be violated, and the resulting TAD missions, CONOPS, and systems could take on a very different character from this evolutionary 2010 vision. For example, the current emphasis on theater missile defense (TMD) versus national missile defense (NMD) could

shift 180 degrees, with increasing investments in NMD and decreasing investments in TMD, if U.S. power projection strategy increasingly emphasizes stand-off systems (e.g., bombers, satellites) to minimize friendly exposure to WMD threats.